

AN
ESSAY
AT THE
MECHANISM
OF THE
Macrocosm :
OR THE
Dependance of Effects
UPON THEIR
CAUSES.

IN A
NEW HYPOTHESIS,
Accommodated to Our Modern and
Experimental Philosophy.

In which are solved several *Phænomena*, hitherto
unaccounted for; as the Cause of *Gravitation*,
Motion, *Reflexion*, *Refraction*, &c.

With a Method proposed to find out the Exact
Rate that a Ship Runs, and consequently the
Longitude at Sea.

L O N D O N :
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G. M. d.

TO THE
Learned and Ingenious
THOMAS LOWE,
Of Bromsgrave, Esquire.

Dear Sir,

THOU I know that the
greatest Patron that e-
ver lived was never able wholly
to Protect Books from Censure,
yet I am satisfied that the seem-
ing Approbation of a Competent
Judge, will frequently Cause them
to be Read with less Prejudice.
And therefore if Custom had not
made it Necessary, it would have

The Dedication.

bin no way adviceable for me, to expose the *First Fruits* of my *Studies*, in such an *Embrio* as this, to the *Public View*, and *Censure*; without *First* endeavouring to provide a *Friend*, whose very *Name*, being *Prefixt* to it, might make it more kindly received: And among all that I have the *Honour* to be acquainted with, I thought I could not *Address* my self, *First*, To a more *Competent Judge*, and therefore a *Fitter Patron* than You, whose *Knowledge* in the *Learned Languages*, has rendred You capable of *Reading* any *Authors*, and that of *Improving* Your *Naturally Acute Judgment* so, as any where to distinguish

The Dedication.

distinguish Truth from Glosses. Secondly, One who makes an Estimate of Things, not according to their Outward Shew, but according to their Real and Intrinsic Worth; and therefore most proper for such a Work as this: whose only Ornament is its Aim at Truth. Thirdly, I have visibly received so many, and so Great Favours and Obligations from You, that 'tis utterly impossible for me, ever to hope to Retaliate; and therefore I think I am bound in Justice, Reason, and Honour to lay hold of the first Opportunity, to make a Public Acknowledgment; which tho' it be in a Way very Unworthy of You, yet I cannot doubt, but Your ac-

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*customed Goodness and Kindness,
will accept of the Endeavours of
him, whose Greatest Ambition,
is to approve himself in Sincerity,*

Your most Affectionate

and Devoted Servant,

Conyers Purshall.

TO THE
READER.

WHEN You look into the First Chapter of the following Discourse, perhaps You'll say, *Ne super ultra Crepidam*, or what has a *Physician* to do with *Divinity*: To which I answer, *First*, That the *Law of Nature*, which is our Province, is the *Law of God*; and it being so, I think it my Duty to confer my Mite in Vindication of the *Legislator*: Especially in an Age, wherein there are so many, that not only Deny His *Power* (as the *Deists*,) but even His *Existence* (as the *Atheists*.) The Latter of which, those of our Faculty have bin peculiarly branded for; Tho' I think 'tis impossible for any Man that is a *Physician*, more than in

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Title, to be an Atheist: For he that looks throwly into the *Nature of Things*, must find a *Deity*, as a First Cause. 'Tis true, a Superficial Knowledge, joyned with a Licentious Inclination, may provoke some Men to think it possible, that many of the *Miracles* mentioned in the *Holy Scriptures*, (which are too well Attested to be denied,) may yet be done by Natural Means, and so to be meer Tricks; upon which their unwillingness to be confined to the Laws therein contained, makes them immediately (tho very Unreasonably) conclude, that they are so, and then to Commence *Atheists*.

Thus they say 'tis possible that *Elijab* upon Mount *Carmel*, (*1st. Kings, Chap. 18.*) might put *Bitumen* under the Wood in the Ditch he made about the Altar, upon which when he poured Water, a Fire would Naturally break out, kindle the Wood, and burn up the Sacrifice. And when they have said this, they put a Fallacy upon themselves, and conclude from the Possibility, that he really did so: But yet they are at a loss, to shew by what Natural Means he could foretell to *Ahab*, abundance of Rain in so short a Time, when there was yet

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yet no Sign of it, as appears by his Servants answer *Verse 43.*

And if they would be at the Pains to look narrowly into those Miracles, they would find something in them, that seems most plausible to be done by Natural Means, that utterly exceeds its Capacity. There have bin some Instances, that the Water of some Rivers, have bin so dammed up by violent Winds, as to have bin Dry downwards; But this could not be the Case of the *Red Sea*, *Exodus 14.* for then the Waters could not have bin a Wall unto them, on the Right Hand, and on the left, as *Verse 22.* the lower side must have bin without a Wall, and tho' it was done by a Strong East Wind, *Verse 21.* Yet there must be something peculiar in that Wind, that it had not the same Force upon the Children of *Israel's* Bodies, as it had upon the Waters; for if it had, it would have drove them up into the Sea also; or if it was such a Wind, that not only separated the Waters, but at the same time Froze them up into Banks (as some suppose,) yet it was still Miraculous to have such Cold Winds about Harvest, in the Month *Abid*, which signifies *Spica*, an Ear of Corn,

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Corn, because Corn was then in the Ear, a Season which seems to be the same with them, as *July* is with us; and therefore *Hieronimus* and some *Neotericks* call it *July*. Besides the *Egyptians* seem to be overwhelmed before the *Israelites* came a Shore, *Verse* 28 and 29, and it was the Angel, and the Pillar of the Cloud, *Verse* 19. that interposing seemed to Protect the One, and Destroy the other. Secondly, I am sensible that *Systems* of this Nature have in the Judgment of very Learned Men bin Conducting to Atheism, and therefore I thought fit in the first Place, to Prove the Existence of a Deity, His Attributes, and the Truth of the Scriptures, upon which I have founded my *Hypothesis*; so that take away those and it immediately sinks. Which I hope may be a just Precaution to that Objection, and excuse me for Writing that which may seem to be the Business of another Man; especially since I have so far kept within my own Bounds, as to make use of no Text of Scripture, till I have proved it True, and consequently very Reasonable so to do, it being consistent with the Nature of a Rational Creature, in his search after Truth, to make use of any just Means that may Direct him to it; and tis

To the READER,

yet more excusable, since this is a Thing that every Body is concerned in, that hopes for Salvation. Tho' I cannot think, but as the Contemplation of the *Nature of Things*, in their Chain of Causes, enlarges the Mind of Man, so it gives it a more Just Idea of their *Creator*; and as they were made for His *Glory*, so His *Power* and *Greatness* is most Radiant in the Knowledge and Contemplation of them: And this I have found by Experience, and wish that the Reader may have the same Benefit and Satisfaction in the Perusing, as I have had in the Writing.

Reader, I must request Two or Three Things from You. *First*, That You will look upon the following Discourse as an *Essay*, and not expect so large a Subject, exactly distributed into its several Branches, duely Discusst, and Exhausted in so short a Treatise as this: Which would be a Work of many Ages, for greater Genius's, with better Opportunities to inform themselves, than an Obscure Country Place affords, where I can have no fit Materials for my Purpose, or Conversation with the Learned, at least in this Way, to inform me.

Secondly,

To the READER.

Secondly, If You meet with any Thing therein, that Surprizes You, as Incredible, that You would not immediately Censure them as *Whims*, *Chimera's*, or *Romantic Stories*, till such times as You have used such Means, that are Necessary to inform Your Judgment, of the Truth of the Matter of Fact, (as the *Microscope*, *Telescope*, *Pneumatic Engine*, &c.) Which when You have done, then Censure freely, Confute them Solidly, and I shall acknowledge it readily, and think my self Obliged to You, as to One that has bin so Charitable as to be at the Pains to reduce me from an Error.

Thirdly. That You would Censure no Part, till You have Read the whole, and then if you Dislike it, and think fit to shew the Absurdity, or Invalidity of it, that you would begin with the *Principles*; or if You acknowledge them, that You would Confute the other Parts upon those *Principles*: For if You should endeavour to shew the weakness of any Part of it, upon any other *Principles*, 'twill inform neither of our Judgments, and but only Cause a wrangling Discourse to no purpose.

Fourthly,

To the READER.

Fourthly, As to the *Astronomical Part*, I must acknowledge, that I have had no manner of Convenience, (in the Place where I am, for making *Nocturnal*, or other *Cælestial Observations* ; wherefore I have had recourse to the Writings of the best *Astronomers*, that I could meet with here, and have endeavoured to range the *Positions*, and *Motions* of the *Cælestial Bodies* so, as may Answer the various *Phænomena* in their Observations, and to assign the Natural Cause of that Order, and of the *Phænomena* that results from them, when placed in that manner. And tho' it may seem a Bold Attempt to reduce the Earth once more to the Centre of the *Universe* ; in an Age wherein *Copernicus* so much prevails, who I must acknowledge has with a great deal of Learning and Ingenuity, more exactly solved the *Cælestial Phænomena* than any (that occur to me) before or since ; yet if it does appear, *First*, That my *Hypothesis* solves all their *Phænomena* as well as his : Or *Secondly*, If my Reasons are just, or such, that it will require some Pains, to shew why such Causes as I there assign should not have such Effects. And *Lastly*, If it more Adequately Answers all the *Phænomena* in *Physics*, I hope it will
free

To the READER.

Free me from the Censure of Arrogancy, and Conceitedness to propose it, tho' in an Age never so much prejudiced.

Fifthly, I must let You know, that I have designedly taken the *Experiments* in the following Treatise, generally from other Authors, (tho' many of them I have tryed my self) well knowing their Authority, will be much more prevalent than mine could be, and in most (of that Bright leading Stars,) the Honourable *Boyle's Experiments*, I have not quoted the *Page*, because some are taken out of His own Works, some out of *Bolton's Abstract*, which I thought might puzzle the Reader: And therefore instead of that, I have put down the *Experiment* it self, that He might Judge the better of it, and have referr'd to the Tract.

Sixthly, That I think it needless to set forth the Use and Benefit that may accrue from the following Discourse, provided it answers its *Title*. Since every Body knows, how advantageous it is, to proceed in a right way, or to Reason upon a good Foundation; and how steadily this Directs to the desired Mark, or the Knowledge of Truth. For
he

To the READER.

he that knows the *Texture, Power, and Properties of Bodies*, and the *Disposition and Modification* of them, that is required to Effect This or That end, will easily know how to *Add, Diminish, Alter, or Dispose* them most conveniently to attain to it : But if a Man that knows nothing of the matter, will take upon him to make an Alteration at a Venture, 'tis a Thousand to One, 'twill be for the Worse ; Because there are a Thousand Ways to Injure any *Machine*, when perhaps there is but One to Mend it.

So he that knows the Use of the *Spring, Fusee, Ballance*, and other *Wheels* of a Watch, if it goes amiss, so soon as he knows what the disorder is, will know where the Fault lies, and how to Mend it : But if one that knows nothing of it, will immediately begin to Hammer, File, Add, Transpose or Alter, tis a Thousand to One, but instead of Mending One Part, he Spoils the Whole. The Case is the same in all other Things ; And therefore the Benefit that will accrue from the Knowledge of *Causes and Effects*, of the *Texture, Power, and Properties of Things* is manifest.

Lastly,

To the READER.

Lastly, That if You expect exact Method, fine Language, apt Expressions, and a flowing Cadency, thro' the VWhole Discourse, You will be deceived: For'twas the Height of my Ambition only to Write, so as to be Understood; and I've used no other Method than what Nature dictated. But if You are one of those Inquisitive Persons, that looks more into the Matter, than the Manner of Writing; I suppose, You may find something that will be Acceptable to You: Which if You do, or but with such hints that may encourage You to a better Performance, I have my End; but yet Wish, that You may have Your expectation also.

A N
ESSAY

A T T H E

Mechanism of the Macrocosm.

C H A P. I.

TH A T there are *Beings*, is as certain as that we are; which being the most Self Evident *Proposition*, is of all others most certain.

And since 'tis certain there are *Beings*, 'tis certain there must be some *Eternal Being*; for if ever there was a *Time* when there was *Nothing*, there never could have been any *Thing*; because *Nothing* cannot produce *Something*.

This *Eternal Being*, must either be an *Animate Rational Being*, or an *Inanimate and Irrational Being*; if the Latter, an *Animate or Rational Being* could never from it be produced; because *Nihil dat quod in se non habet, & nihil operari potest ultra gradum suae perfectionis*, or *Nothing* can make a more perfect *Being* than it Self: and because I am assured, as much as I can be of any thing, that there are *Animate Rational Beings*; I am sure there must be some *Animate Rational Eternal Being*, from whence those that I am conversant with had their *Original*; or otherwise they

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must be *Self-Existent*, and consequently *Eternal*; (which from their Birth and Death, I am sure they are not,) or the *World* must be in the same Perfection from *Eternity* as 'tis now, and they must proceed from an Eternal and Successive Generation, but that the *World* was not in its Perfection from *Eternity*, and consequently not they, I shall prove thus,

First, If the *World* were in its Perfection from *Eternity*, it could never suffer so great an Alteration as *Noah's Flood*; for that which hath *Eternal Duration*, has the *Eternal* same Perfection and Essence to *Eternity*, as from *Eternity*, as well *ad partem post*, as *a parte ante*, and therefore must be free from all Accidental Defects and Deformities, such as this must be acknowledged to be; which had been an irreparable Destruction of all the *Species of Living Creatures*, had not *Divine Power* shewed it Self in it, when the Element of the *Earth* was lost, and Water possess the Place of the *Air*, and the Whole was almost reduced to a *Chaos*.

Now, no Insensible *Motion* of an Involuntary *Agent* could produce such a Defect; for if meerly by the jussling and clashing of Material Inanimate *Particles* or *Atoms*, it had a Tendency to such a Deformity as the *Deluge*, it must arrive to it in less than *Infinite Space*; but from *Eternity* to the Production of this Effect is an Infinite Inconceivable *Space*, because betwixt that which hath a Beginning, and that which hath none, is no Comparison; for if the *World* upon the Account of the Luctation, or Disorder of its different Constituent Parricles, should have a Natural Tendency to such Defects at certain Stated Periods; let them be at never so great a Distance, yet in *Eternity* there must have hapened Infinite *Deluges* or Deformities, and consequently Eternal Deformities

mities ; because there is no difference betwixt *Infinite* in *Time* and *Eternal* : for suppose there be 100000000000 of Years betwixt each *Deluge*, yet at the end of each 100000000000 of Years, there would be a *Deluge*, and then if we look back till there have been Ten hundred Thousand Millions of Millions of *Deluges*, and though we continue to increase the Number in a *Decuple Proportion* or Manner as long as we live, we shall be no nearer *Eternity* than at First ; for nothing but *Infinite* can End in *Eternity*.

Besides, it will follow, that there have been as many *Deluges* at such Distances, as there have been *Years*, and as many *Years* as *Days*, and as many *Days* as *Hours* or *Minutes*, or these last can be but Infinite ; so that the Part must be as big as the whole : and there must actually have been as many *Armies* or *Millions of Men*, as single individual Persons, and many such like Absurdities. On the other side, the World hath had its Lucid Times or Periods of such Perfections as we see now, and consequently in *Eternity* hath had *Infinite* Lucid Periods or Times of Perfection, and therefore hath had *Eternal* Perfection, for if there had been any Time in which it had not been in Perfection, it would have wanted that Time of being Infinite ; and so if this holds, both Parts of a contradiction may be true, there may have been *Eternal Night* and *Eternal Day* (for there must have been *Infinite Nights* and *Infinite Days*) in the same Place, which is impossible.

That there was such a *Deluge* as *Noah's Flood*, is manifest, not only from the Testimony of Sacred Writ (which is sufficient) as I shall prove hereafter ; but from the Histories of divers Profane Authors, such as *Berosus* the *Caldean*, *Hierom* the *Egyptian*, Writing the Antiquities of the *Phenicians*, *Mna-*

seus Nicholas of Damascus, &c. mentioned by *Josephus*, and many others; besides which, there are many Marks yet left of it, as those *Oaks* found in Bogs in *Ireland*, and *Fir-Trees* in *England*, even in the highest Ground, viz. *Bromsgrave*, *Lickey*, and so proportionally all over the World where there are Bogs; as likewise Secondly, those real Shells found near *Reading* in *Barkshire*, mentioned in the *Philos. Transact. Number 261.* in a Letter from *Dr. James Brewer* to *Dr. Sloan*, which is as follows; *Jan. 15. 1699.* 'I ask your pardon that I am so late in performing my Promise, 'in sending you the *Oyster-Shells*; as for the Original of them, 'tis a Province too Nice for me to 'solve, you see they have the intire Figure, 'Form and Matter of *Oyster-Shells*, and no 'doubt they are such: But how they should come 'to the Place where I dug them up, and where for 'so many succeeding Ages they have been found, I 'leave you, and other Philosophers to determine: 'they do Encompass near Six Acres of Ground; 'just above the Layer of these *Oysters*, there is a 'Greenish Earth, or rather Sand, and under 'them there is Chalk. Sir, I have often seen in 'Chalk-Pits a few scattered *Oyster-Shells*, but in 'this Place they are, as it were, in One continued 'Body, and in an even Line through the whole 'Circumference, betwixt Five and Six Acres of 'Ground; you know we have no Sea near us, 'and therefore it seems the more Strange, how 'these Shells should be placed in such a 'Compass of Ground.

And Thirdly, those Petrified Shells which are found in Beds dispersed over all the Earth, even on the Tops, and Sides of the highest Mountains, which could be brought thither by no other probable Means, than an *Universal Deluge*, which
over-

overflowed all the Earth, and covered the Tops of Trees, and Highest Hills.

Which *Deluge* was occasioned, as Sacred Writ relates, by a Violent *Rain* all over the Face of the Earth, for Forty *Days* and Forty *Nights*; which *Rain* must descend from the *Clouds*, and those *Clouds* must proceed from *Vapours condensed*, and those *Vapours* must arise from the Sea, and Humid Parts of the Earth; in which time, as there was a constant Descent of *Rain* from the *Clouds*, so there must be a continual Ascent of *Vapours* arising from the Sea, &c. to supply those *Clouds*: So that between the continual Ascending of the One, and Descending of the other, I conceive there would Result such a mixture of Air and Water, which together with *Terrene, Saline, Unctuous* and *Mineral Particles*, which it would wash from the Earth, would cause such a Fermentation, that would *Rarifie* and Dilate, the whole Bulk of Water to that Degree, as might cause it to take up more than double the Room it did before, and consequently to overflow its Bounds, and to cover the Whole Earth, even to the Degree above mentioned; (especially if highly Agitated, as we may easily suppose it was,) in which Time, by Reason of its Impetuous Agitation, those Shells then contained in the Bottom of the Sea, might be carried with the Rapidity of the Current all over the Earth, and striking against the Mountains, might especially fall down in great Abundance, at their Bottoms or Sides, and those that fell in such Ground, that was imbued with Petrifying Salts, or Chalky dry Earths, were rendred thereby durable Monuments to Posterity of a *Universal Deluge*.

That the *Air* is capable of being mixt with

Water, is Evident from those Mists and Foggs, which are little else but Air and Water; and that the Air so mixed is capable of Dilating the Seas, is apparent from the Observations of the Illustrious *Boyle* : who in his *General History of the Air*, pag. 36. gives this account, that a Mist coming driving upon the Sea towards the Shore, without any Sensible Wind, will raise a greater Swell of Sea, than a Brisk Wind will do.

And the Gravity of those Rarified Waters might be supplied, and rendred Capable of carrying the *Ark*, by the Mixture of Saline Particles which they had Imbibed from the Surface of the Earth; which from the Sacred Text, *Amos* 9. v. 5, 6. and *Psalms* 46. v. 2, 3. seems to be Totally dissolved; which is confirmed by many Natural Reasons, as the subsiding of Earth in Beds, according to their Gravities, the heaviest First, &c. And that Washing away of Saline Particles from the Surface of the Earth, seems to be confirmed by the Infertility of the *Post Diluvian Earth*, and the Saltness of the Surface of the Sea Waters, the Fruitfulness of the former chiefly depending upon these Particles; as *Glauber* has proved by many Experiments; and possibly 'tis from this Unfruitfulness, and the Noxious Steams that Result from the *Heterogeneous Mixtures*, of *Saline* and *Mineral Particles*, made at that Time, and continuing yet Vitiated thereby, that the Lives of the present Inhabitants, are much shorter than those of the *Antidiluvian Earth*, in which the *Saline Particles* were Pure and Free from *Mineral Mixture*.

If any Man doubt whether there are such Petrifying Soils, let him Consult *Adrianus Toll's History de Gemmis & Lapidibus*, who Assigns you the Place, where such Petrifying Earths and Waters

Waters are. Some, that will Petrifie any Thing in Fifteen Days, others in which whole Trees are turned into Stone; and this in most Parts of *Europe*, as *Italy, Germany, Hungary, France, Bohemia, Ireland, Scotland, &c.* and I may add *England*; for I do conceive most of the Earth about *Oxford* and *Astrop* is of this Sort. And I remember, I was walking once in *New Parke* with some others, from whence we went into a Grass Close, as I remember behind *Wadham College*, where we saw a great many *Oyster-Shells* had been thrown out, and in the Path Way we saw several of them sticking, some of which when we had taken up we found Petrified; and among the rest One so exactly, that *Mr. John Alder* (an Ingenious observing Gentleman,) who was then with me, and is now Fellow of *Pembroke College*, took Home along with him, as a Rarity; which I do really believe was a Shell, as likewise the Rest, thrown out of that *Colledge*, and Petrified by that Soil; it would be very well, if some were Buried on purpose in that Soil, to try the *Experiment*.

That the *World* is not *Eternal*, and that these *Animate Rational Beings* with which I am Conversant, (*viz. Men*) are not Self-Existent, nor the Products of meer Matter, hath been proved; from whence I conclude, that since there are such *Rational Beings*, there must be some *Eternal Rational Being*, from whence both they, and the *World* had its Original Existence, (not by such an Emanation as makes God a necessary Cause, so that *posito Deo ponitur Mundus*, as *Aristotle* would have it; for then the *World* must be of the *Essence of God*, and consequently must be of an *Infinite Intelligent Being*, such as the *Second and Third Persons* in the *Holy Trinity*, for

the same Reason are, which is inconsistent with dull Inanimate Matter,) but by *Creation*, or by a deliberate, and determinate Act of his Will; and consequently must have their Beginning in, or with Time; and since they are so, (*i. e. Rational*) their First Cause must be more so, for *propter quod unumquodq; est tale illud est majus tale*, and because it is the *First Cause*, it must be of it Self so, and *Eternally* so, and consequently *Ininitely* so; and what is *Ininitely Rational*, must be *Infinite in Wisdom*; because Wisdom consists in Thinking, Judging, and Acting Rationally.

Secondly, In Power; for since there are such Subjects made, they must be made out of Nothing, or out of meer Matter, or *Materia Indisposita*; now that Agent that can make Something out of Nothing, or an *Animate Rational Being*, or *Creature*, out of meer Matter, or Matter indisposed and *Inhabitable*, is by the Universal Consent of all Mankind *Omnipotent*.

Thirdly, He that is *Infinite in Power*, and *Wisdom*, must be *Infinite in Goodness*; otherwise he might do Infinite Mischief; but that is inconsistent with *Infinite Wisdom*, because 'tis better to do *Good* than *Evil*; and this is highly manifested to us, for he out of his meer Love and merciful Kindness, made us out of *Nothing*, (or out of meer Senseless Matter, which is next to Nothing, and in respect to it Self all one as if it were Nothing, since it hath no Perception of its Being,) not only to be capable of Sensual Pleasure here, but to Reason and Contemplate his *Infinite Attributes*, and to see him, and participate of his *Everlasting Blessedness* hereafter, a Felicity for which the *Cberubims* and *Seraphims*, with *Infinite Reason*, and Gratitude continually do Cry, *Holy, Holy, Holy Lord God Almighty, Heaven and*

and Earth are full of the Majesty of thy Glory, and the whole Host of Heaven, Saints, and Angels, and Glorified Beings, have just Cause earnestly to break forth their *Eternal Hallelujah's*, Praise and Thanksgiving, for so Great, so Unspeakable Benefits, and to Purchase this, he requires no more of us, than that we will do Nothing that is hurtful to our Selves ; for he hath been pleased to make Nothing Sin, that is displeasing to him, but what is Destructive to our Nature, and thereby a Disorder to the *Creation*, which is his Act, and he his Enemy that opposes it, or seeks to Destroy or Injure it ; and after-all, when we persisted obstinately to oppose him, and wallowed in Sin and Wickedness, he found out such an expedient to retrieve us, as Nothing but *Infinite Goodness*, could ever have contrived for us.

But it may Objected, he hath made some, that are Sunk in *Eternal Miseries* : to which I answer, 'twas *Infinite Goodness*, even to them, to raise them from *Nothing*, and to Place them in such a Condition, as upon such easie Terms was capable of *Everlasting Blessedness* ; and 'twas their own obstinate Wilfulness, in not accepting, that plunged them in so great and unspeakable Ruin. But 'tis still disputable, whether the most Miserable of those Wretches, would not rather choose to endure their Pains, than cease to be. Nay, I am apt to think they have Pleasure, (tho' it being compared to the *Joys of Heaven*, is unspeakable Misery) and delight, in that which is the Cause of all their Pains, (if it be not the Pain it Self,) *Viz.* in their Hating and Malicious opposing their *Maker*, and to that End they please themselves, and rejoyce when they Succeed in their endeavour, to destroy the Order of the *Creation*, by making any *Creature Miserable*, and so thwart

thwart God, who undoubtedly designed all his Creatures, to be Happy in their Places and Degrees, (as is evident by all the *Sacred Laws*, which are manifestly designed for that End,) like some Malicious and Envious People, who grieve to see any Body Happy, and delight in Tyrannizing and making their Families and Servants, and all that are about them uneasy; though in the doing of it, they make themselves Miserable, and suffer more than all they design to hurt, by robbing themselves of that Delight and Complacency they might have in them, and grieving at their Prosperity, it being to them the greatest Disappointment; yet these desire to Live, if it be only to be Vexatious and Troublesome to others.

It may be farther Objected, that he might have made their Nature such, as might have restrained them from Sin and Wickedness, and kept them to their Obedience; to which I Answer, that 'twas his Pleasure and Goodness to make *Adam* and *Eve* (whose *Disobedience* was the Cause of all our Evils,) *Free Agents*; and necessitated not at all their Natures, as he did the *Brute Beasts*, who eat when Hungry, Drink when Thirsty, and Lust only at Stated-Times; but instead of that, he left them to their Liberties, and gave them *Reason*, to govern their Actions, and *Judgment*, to choose the *Good*, and refuse the *Evil*; and therefore all the restraint God could lay upon them to resist the Devils Temptation, must be such as was consonant to their Free Will; for God to have given them such powerful Influences of the Spirit, as to have made it impossible for them to Sin, had been in effect to have altered their Natures, and to have changed them from free to necessary Agents; all that we can suppose reasonable for God to do, is to dispence to them
such

such abundantly sufficient Measures of his Grace, as might enable them to Encounter the strongest Temptation; but yet in such a Way as might be consistent with their Reason, and Free Will, for God had then put them upon a State of Probation; but to have over ruled their Actions, and determined them only to one Side, would have been to have run Counter to his own Design, it would have been to have put them on their Tryal, and at the same Time to have rendred them impossible to be tryed: But since he hath made them *Rational Creatures*, 'tis reasonable to suppose he will deal with them as such, *i. e.* Such as have Power to collect, and compare One Thing with another, and to perceive their Agreement and Disagreement, and to Choose or Refuse either of them as they are more or less acceptable, or useful to him.

Thirdly 'tis Objected, that *Infinite Knowledge* foresees and knows all our Actions, (both Good and Evil) before we are Born, and therefore we are necessitated to Act, and do as he foresees. I deny the Argument, and answer, that as God is *Infinite in Wisdom, Power, and Goodness*; (as has been proved) so he is *Infinite in Knowledge*, for he cannot be *Ininitely Wise*, that hath not *Infinite Knowledge*; and 'tis Manifest from what hath been said, that if there be a God; (as there must be if there be any Thing,) he must have these Attributes; and then it will follow, that they are not only consistent with each other, but necessary, so that *posito uno ponuntur cetera*, and then 'tis certain that an *Infinite Power*, that is, *Omniscient* can make a Rational Creature, or a Creature indued with a Free Will, without necessitating him to Evil Actions by his *Præscience*; otherwise the *Knowledge* of God would Destroy his

his *Wisdom* which is absurd, or One *Attribute* would Destroy another, which is impossible, as has been proved ; for to punish a Creature for doing an Act that he cannot avoid, is Inconsistent punish a Creature for an Evil Act, that Acts *ad libitum*, or has Power to do it, or not to do it, is Inconsistent with *Infinite Wisdom* and *Justice* ; with *Infinite Wisdom* and *Goodness*, and not to to say he will punish a Creature for an Evil Act, and not to do it, is Inconsistent with *Infinite Wisdom* and *Truth* ; and therefore since 'tis certain that there is a *Creature*, whose Actions he has Promised to Punish or Reward, 'tis certain there is a *Creature* whose Actions are Undetermined, either by his *Præscience*, or any other way ; so that that Inference must be false, or the *Infinite Attributes* must Destroy each other.

And I think 'tis much more Rational to Conclude, that *Infinite Wisdom*, *Power* and *Goodness*, can find out a Way to Communicate a Free Will to his Creatures, without destroying his *Infinite Knowledge*, than that a blind and uncertain Inference should be true.

And 'tis always a blind and uncertain Inference, where there is any Term in the Premises, that is not, or cannot be understood, as in this Case, where the Term *Infinite Knowledge*, is put in opposition to *Infinite Power*, *Wisdom*, *Goodness* and *Truth* ; the Energy, Power, Operation or Limits, of either of which can never be understood by a Finite Understanding, and therefore the Inference must be blind and uncertain.

If *Infinite Power* be a Power answerable to the Will, or capable of affecting any Thing that he shall Will (as it is, for if he can Will any Thing that it cannot do, it cannot be *Infinite*.) it is easy to conceive that he may Will a Creature, that shall

shall have Power to Act freely, without being determined by his *Præscience* or otherwise; and how this may be done, may be known to *Infinite Wisdom* and *Knowledge*, tho' not to a *Finite Understanding*; and therefore any Inference we can make in this Matter is made at a venture, till we know how far *Infinite Wisdom* and *Power*, can adjust One Thing with another.

But it must be acknowledged, that this *Free Will* is so United to the *Body*, that it receives almost all its Impressions from the *Corporeal Senses*, by which the immediate Pleasures of the *Sensual Appetite*, are represented to it with so much Advantage, that 'tis impossible for a Man (since *Adam Sinned*,) and not influenced by *Grace*, or *Divine* or *Humane Laws*, always to deny their irregular Gratifications; but this is not because the *Will* is not *Free*, but because the *Sensual Appetite* is more prevalent with it, than his *Reason*, which God hath given him to direct in that Case, the Use of which he neglects, and therefore the Fault is his; so that tho' the *Will* is always *Free* from constraint, yet 'tis so embarrassed by the *Sensual Appetite* or *Affections*, that in a State of *Nature*, it cannot always so attend to Reason, as to do that which is Good or Fit to be done, without the Grace of God inclining and enabling it; and indeed 'tis difficult to conceive how a Man, not restrained by Grace, or deterred by *Divine* or *Humane Laws*, should ever do an Act of Self-denial, or deny the Gratification of the *Sensual Appetite*.

From what hath been proved, 'tis evident, that God must be a *Being Infinite in all Perfections*; for he that is *Infinite in Wisdom, Power, Goodness, and Knowledge*, must be *Infinite in Truth, Justice, Mercy, and all Perfection*; for a Defectibility

fectibility in these is Inconsistent with *Infinite Wisdom, Power, Goodness and Knowledge ; Truth, Justice, Mercy, being Preferable to Lying, Cheating, Tyranny, and consequently are the Objects of Infinite Wisdom, &c.*

Now if God be a *Being Infinite* in *All Perfection* ; what ever he says, in the Sense that he speaks it, must Certainly and Infallibly be *True*, how Cross or Contradictory soever it seems to my Reason or Judgment ; for Deceit or Falsity argue Imbecility and Defect, and consequently are Inconsistent with *Infinite Perfection* ; and therefore when I find any Thing in God's Word, that seems above, or contrary to my Reason, I conclude notwithstanding that 'tis infallably *True*, because 'tis spoken by One who cannot Lie, and that 'tis the Weakness of my Judgment that cannot apprehend the meaning of it, as 'tis intended, or the Nature of the Thing that it relates to, which surpasses my Understanding ; as for Example, God by his Word tells me, that there is the *Father, Son and Holy Ghost*, and that the *Father is God, the Son is God, and the Holy Ghost is God*, and that these are Three distinct Relations, and yet but *One God* ; this seems to me at First, who Judge of Things at a distance, by Things that are Present, to be Inconceivable and Contradictory ; that *Three* should be but *One*, seems to Argue that they should be *Three* and not *Three*, and if it were spoken of *Finite Beings*, 'tis impossible it should be otherwise ; but when I consider that 'tis spoken of *Three Infinite Beings*, 'tis so far from Nonsense and Contradiction, that 'tis highly Reasonable, nay impossible that it should be otherwise ; for if the *Father, Son, and Holy Ghost* be *Three distinct Persons or Relations* ; that is the *Father* is not the *Son*, nor the *Son* is not the *Holy Ghost*, and

and the *Holy Ghost* is not the *Father* or the *Son* : If the *Father* be a *Being Infinite* in all *Perfection*, the *Son* be a *Being Infinite* in all *Perfection*, and the *Holy Ghost* be a *Being Infinite* in all *Perfection*, these *Three* must be *One* and the same *Mind*, *One* and the same *Will*, *One* and the same *Essence*, *One* and the same *Power*, &c. which I prove thus, that is the same *Mind* which thinks the same *Thought*, and can do no otherwise, the most perfect *Thought* in any *Case* is the same *Thought* ; but *God the Father*, *God the Son*, and *God the Holy Ghost*, being *Infinite* in all *Perfection*, think the most perfect *Thought*, therefore the same *Thought*, that is the same *Will*, which *Wills* the same *Act*, and can do no otherwise ; the most Perfect *Act* is the same *Act*, and they being *Infinite* in all *Perfection*, must *Will* the most Perfect *Act*, and therefore the same *Act*, that is the same *Being* that is in the same *Place*, and can be no otherwise ; but *God the Father*, *Son* and *Holy Ghost*, being *Infinite* in all *Perfection*, are *Immense*, and every where ; and consequently in the same (*Place*) or *Immense Ubiquity*, and therefore the same *Being*, *Omnipotent Power*, is the same *Power*, & sic de cæteris.

That they are *Three distinct Persons*, is likewise deducible from the *Scriptures* by necessary Consequence ; and therefore infallibly *True*, (if the *Scripture* be the *Word of God*,) thus, a *Person* is an intelligent speaking *Being*, (or hath a *Power of speaking*,) to whom the *Personal Particle* may be properly applied.

That He that made the *Tongue* can *Speak*, and is *Intelligent*, needs no *Probation* ; and the *Personal Particles* are properly applied to him ; i. e. to the *Father*, and likewise to the *Son* and *Holy Ghost*, or else *Infinite Wisdom* speaks improperly, which

which to Affirm is Absurd, and little less than Blasphemy; for in the 16. and 17. Verses of the 14. Chap. of the Gospel of St. John, I read thus, *I will pray the Father, and he shall give you another Comforter, that he may abide with you for ever, even the Spirit of Truth, whom the World cannot receive, because it hath him not, neither knoweth him; but ye know him, for he dwelleth with you, and in the 26 Verse, He shall teach you all Things, and bring all Things to your Remembrance, whatsoever I have said unto you.*

Here the Personal Particles are properly applied to Three distinct Intelligent Speaking Beings, who consequently may be called *Persons*; the Particle *I* is properly applied to the Son, the *Person* Speaking, distinct from the Father, the *Person* He will Pray to; and *He*, here the Particle *He* is applied to the Father, *He* shall send a Third, or the Comforter, or *Person* spoken of, distinct from either of the Two, to whom the Personal Particle, *He*, is likewise apply'd, that *He* may abide, *He* shall teach you all Things, and bring all Things to your remembrance, &c. Now *He* that can teach all Things, must needs Understand all Things himself, and therefore is an *Intelligent Being*.

The Truth of the Scripture, provided it be the Word of God, hath been proved already; and that it is so, is evident, because its *Authors* or *Promulgators* do Affirm it so to be, and ratifie their Assertion, by doing those Things, that utterly exceeds all Humane, or indeed any but *Omnipotent Power*, viz. By altering the Frame of Nature, doing Things contrary to it, or without it, which if the *World* were *Eternal* were impossible, and as it is can be altered by none, but the *Omnipotent Power* that made it, which proves invincibly that *there*

is

is a God ; because there is a Power that can Command it, and has, by doing those *Miracles* mentioned in the *Old* and *New Testament*, which shews that what they said was declared to them by that Power, viz. by God Almighty Himself, who enabled them to do those Things in Confirmation of it, which no other Power could do ; such were the *Miracles*, and Foretelling of future contingencies and Prophecy which they did, and is Recorded of them all along throughout the *Old* and *New Testament*, and upon which all the greatest Mutations of Government in the World depended ; (as the *Persian, Gracian, Roman, &c.*) and by which they were foretold, and in their due Time fulfilled : So that, except the *Types* and *Figures* in the *Old Testament*, were intended to set forth a Counterfeit ; except the *Prophets* should foretel future Contingencies, by a *Spirit* that was not of God ; or that the God of Truth should do *Miracles*, to confirm a Lie ; which cannot enter into the Heart of Man to conceive, it being irrational and impossible ; they must be the Word of God, if these things were done.

And that they were done, is the Assertion of all, both *Jews* and *Christians*, in all Ages, and in all Places ; and is manifest by being quoted the same, as they are now, by all Authors, in all Times, from *Moses* even unto us. And it cannot reasonably be supposed, that so many Men, living in so many several Ages, and at such vast Distances from one another, who some of them it may be, never heard of the Names of some or other of them, should conspire to cozen themselves, and all the World besides, in a Matter of Fact, not at all to their own advantage ; with such exact Consent and Agreement with each other, in
C driving

driving on the same design, and persisting in it,
 against all Oppositions and Allurements to the
 contrary ; so that no promise of Wealth, Ho-
 nour or Promotion, can persuade them to for-
 bear evidencing the Things that they had seen
 and heard, when being brought before *Kings*
 and *Rulers*, and strictly threatned to hold
 their Peace ; they were thereby rather embold-
 ned to speak: when being Wracked and Tortured
 to relent their Evidence, they continued in the
 midst of the greatest Torments, to Witness the
 same thing they did before. And in fine, when
 having a certain prospect before them, of loos-
 ing all that was dear to them in this World,
 and even Life it self, unless they would either
 go back from what they said, or at least for-
 bear to repeat and confirm it ; which rather
 than they will do, they willingly and cheer-
 fully, Seal their Testimony with their Blood :
 and this being the best and greatest assurance,
 that we can have of the Honesty and Veracity
 of any People, that Witness a Thing only of
 their own private Knowledge ; He's an unrea-
 sonable Man that desires more, or says this is
 not sufficient. As an Ingenious Man argues,
 that read some of *Mr. Boyles Lectures* : But
 yet there is a greater Evidence, that is, the Au-
 thority of God shining in the *Holy Scriptures*,
 which doth abundantly and uncontrollably, ma-
 nifest them to be the Word of the living God.
 So that meerly on the Account of their own
 proposal, of themselves unto us, in the Name
 and Majesty of God, without the Contribution,
 Aid or Assistance from Tradition, Church, or any
 Thing else, without themselves, we are ob-
 liged upon the Penalty of Eternal Damnation,
 to receive them, with that subjection of Soul,
 which

which is due to the Word of God, they affording us all the Divine Evidence of themselves that is needful for us.

‘ For when they are thus offered, if they be rejected, it must be not only with a refusal of their Witness, but also with a high Detestation of their Pretence to be from God ; for if the *Scriptures* are, what they reveal and declared themselves to be, they must then undoubtedly be the Word of the living God, and Truth it Self ; for such it professeth of it self from the Beginning to the End, to which Profession, all that it reveals, answers absolutely and unquestionably in a tendency to his Glory : If it be not so, it must be acknowledged that the Author of it, had a Blasphemous Design to hold forth himself to be God, who is not ; a Malicious intention to deceive Men, and to make them believe that they Worship, and Honour God. when they do not ; and so draw them into everlasting Destruction, and he that can do thus, must certainly be the Devil. Now certainly, while Men continue Rational, and can in any wise distinguish betwixt Good and Evil ; tis impossible for any Man to think, that that Doctrine which is so Holy and Pure ; so absolutely leading to the utmost improvement of whatsoever is Good, Just, Commendable, and Praise Worthy ; so suitable to the Preservation of Man, and all that’s Good, could proceed from any one everlastingly hardened in Evil ; and that in pursuit of the wickedest Design, that that wicked One could possibly be engaged in, *viz.* to Enthroned himself, and maliciously to Cheat, Cozen, and Ruin the Souls of Men : so that upon necessity, the *Scriptures* can own no Author, but

' Him whose they are, even the living God ;
 ' and when it is thus tendred, if it be a Sin to
 ' refuse it ; 'tis a Duty to receive it, if a Duty
 ' to receive it as the Word of God, then it is
 ' sufficiently manifested so to be, by an Impres-
 ' or Beaming of the Majesty, Truth, Holiness
 ' and Authority of God, given unto it, and left
 ' upon it by the Holy Ghost ; by which it dives
 ' into the most secret recesses of its Heart, and
 ' determines, and convinces the Consciences of
 ' Men, in the Name, Majesty, and Power of the
 ' ever living God its Author.

CH A P. II.

TH A T the *World* is not *Eternal*, nor pro-
 duced by meer Matter has bin proved ;
 and therefore was made (there being no other
 conceivable way) by that Power, which has
 bin proved to be *Infinite* in *all Perfection*,
 and consequently capable of doing it ; as 'tis
 affirmed by those *Scriptures*, which have bin
 proved to be the Word of God, and consequent-
 ly *infallibly True*.

And since they are *infallibly True* ; I may as
 reasonably Argue from them, and be as certain
 of finding out the Truth, as from any the most
 received *Maxim* or *evident Demonstration*, that
 it was made after the manner that they have re-
 lated it ; viz. from a *Chaos* or *Mass of Matter*
Created by God for that Purpose, consisting of
 such different Particles, as were Fit to be dispo-
 sed according to his Predetermination. (I say
Created

Created, because it only was *Created*, properly speaking, *ex-nihilo*; for all those *Secondary Bodies*, that are compounded of Matter, are rather *Produced* than *Created*: and it cannot reasonably be supposed, that such a *Mass*, should consist directly of such Active Principles, being exactly adequate to such a *Motion*, as was most proper for the ranging and disposing of all the Passive Particles therein contained, by Actuating and Combining them in such Order, Proportion, and Variety, as we find them in all the *Compound Bodies* of the *Universe*, and they most proper to be so Disposed, Ranged, and Combined, &c. should be the meer Product of *Chance*, or *Eternal*; and not designedly made by the *Divine Architect*, in such Form and Proportion, as was most agreeable to the *Fabric* he designed, and they appear to be by the infallible Word, *Psalms* 16. 4. *The Lord hath made all Things for himself.* and *Rom.* 12. 6. *Thou hast Created all Things, and for thy Pleasure they are and were Created*; and since they were *Created* by a *Being Infinitely Wise*, they must be *Created* such as was most exquisite, and would best answer all those *Motions*, *Mutations*, and *Productions*, which were designed in that *Machine* they were to Produce, when disposed in such order as we now see in the *Universe*; otherwise they would not have been proper for the *Ends* to which they were *Created*, which would have argued Weakness in the *Artificer*, which to think, would have bin *Prophane* and *Idle*: for who can Imagine, that he that could produce them out of *Nothing*, could not, or would not make them such as was most convenient for his *Work*.

Now to search out what these *Particles* or *Principles* are, because we cannot look into the *Chaos*, to examine what they were there, we must try whether we can find them in that *Body* which is compounded of them, and in which they are ; for whatever *similar Principles* we find in its *Composition*, the same were in its *Generation*, for they cannot have bin disposed in such *Order*, except they had *Pra-existed* before they were so disposed : for if we look into a *Watch*, and see Variety of *Wheels*, *Springs*, and other *Materials*, disposed in such manner, as is most convenient to effect those Ends designed by that *Engine* ; we cannot but conclude those *Wheels* were framed in the same manner, before they were put into that *Order*, and 'tis that *Disposition* that renders them capable of these peculiar *Properties*, that distinguish it from all other *Engines*, and denominate it a *Watch*. So when we look into the great *Machin* of the *World*, and see that stupendious Variety of *Phænomena*, that depend on *Particles* disposed in such *Order* and *Proportion*, as is requisite to produce such *Effects* ; we must Conclude that those *Particles* had Existence before they were so Modified, and then they must be those contained in the *Chaos*, there being no other Repository before the *World* for that Purpose.

By *Particles*, or *Principles*, I understand those most simple *Minima's of Matter*, which are so small, that there is no *Agent in Nature* can make them smaller, or divide them farther, immediately Created by God, out of which all *Bodies* are compounded, and into which they are *Ultimately* resolved.

From whence it follows ; First, that being *Created simple Beings*, they have not their Original from any other Matter, for if so, they could not be *Principles*.

Secondly, They have *Length, Breadth, and Thickness*, otherwise they could not give *Length, Breadth, and Thickness*, to any other *Body*.

Thirdly, Tho' they are never so small, yet each of them has a *Place* ; so that no other can be in the same *Place* as this, at the same *Time*, and consequently are *Impenetrable*.

And therefore Fourthly, Neither subject to *Generation*, nor *Corruption* ; tho' some of them must be allowed to undergo some Alteration, in their *Luftation*, and *Combination* with other *Particles* ; for *Generation* is the Modification of different *Particles* by *Actuating, Dividing, Transposing, Mixing, Connexing, and Uniting* into this or that form ; *Corruption* is the *Dissolution* or *Separation* of *Particles*, so modified: whence,

Fifthly, It follows, that they must be of divers Kinds, for *Generation* is the *Modification* of different *Particles* : for if they were not different, there could not be different *Productions*, for the same *Principle* will still have the same *Effect*, and make the same *Thing*: whence,

Sixthly, It follows, that there must be great Numbers of *Similar Particles*, or *Particles* of the same Kind, sufficient to be dispers'd, either as *Material*, or *Efficient Causes* thorow all the *Bodies* of the *Universe* ; (at least which are near or round about us :) for if there were no Number of *similar Particles*, there could be no distinction of *Principles*, but every *Corpuscle* must be a *Principle*.

Now looking into this astonishing *Machine* of the *World* ; I only find these Eight, of which I therefore Conclude it, and all Things in it, are *Composed*.

Viz. *Æther, Niter, Air, Spirit, Oil, Water, Earth* and *Salt* ; the Two First, are *Principles* of an extreamly Springy Texture, tho' of different Determinations, which makes them Act on each other as contraries ; for which Reason I shall call them *Active Principles* : The Two last viz. *Earth* and *Salt*, have no *Spring* at all, and consequently no *Motion*, but what they receive from others, for which Reason I shall call them *Passive or fixt Principles* : The *Air* has a manifest *Elastic Spring* like *Æther*, and so may be accounted *Active*; but by Reason of its violent compressed Condition, its *Spring* is so Faint and Languid (compared with *Æther*,) and so weakened by intermixt *Particles*, that it participates of Two extreams, and may therefore be accounted among the mean. *Spirit, Oil, Water*, are *Principles*, which tho' they are of a *Springy Texture* ; yet seem in themselves to have a Natural Tendency to *Quiet* and *Rest*, till they are put in Motion by others, and they then move violently ; and being of this *Nature*, they seem to be that Bond of *Unity* or *Medium*, by which the Extreams are united and agree in the *Compound*. But for the better understanding of these Principles, upon which all the *Phænomena* of the *Universe* do chiefly depend, we will consider each a part.

C H A P. III.

FIRST we will begin with *Æther*, which from what has bin said, may be defined to be a *Principle* of *Matter*, of a most Subtile, and Expansive *Springy* Texture : But because we cannot go up to them, to examine whether they are such or not, we must judge of them by these that come down to us ; I mean the *Solar* Particles, which are *Æther* (as shall be shewn hereafter) put into a most Violent Rotatory *Motion*, by the Strokes of the Body of the *Sun* ; from whence they are darted down even unto us, and much farther, of a *Globular Figure*, like the Spring of a Watch wound up : From whence it appears, First that they are *Matter* ; Secondly, of a most Expansive *Springy* Texture ; Thirdly, of a *Globular Figure* ; and Fourthly, put into a Violent Rotation. First, that they are *Matter* ; that which may be touched by *Matter*, must be touched in One *Point*, and that which may be touched in One *Point*, may be touched in Many ; for that which, *Physically* Speaking, has a *Point* in *Length*, has a *Point* in *Breadth*, and *Thickness*, and that which has *Length*, *Breadth*, and *Thickness*, has *Figure*, *Size*, *Weight*, &c. and consequently all the *Properties* of *Matter* ; and that which hath all the *Properties* of *Matter* is *Matter*.

Which seems to be confirmed, First, because they may be *Reflected*, viz : from a plain Looking-Glass, either *Directly*, *Obliquely*, or any other

ther Way *ad libitum*; as a Ball from a Racket, or any other *Elastic Body* from a Wall, or any other hard Substance can be; and that which Reflects any Thing, must first touch it, before it can beat it back or Reflect it. Secondly, because they may be Scattered by a *Convex*, and Collected by a *Concave Speculum*.

Thirdly, Because they can put *Bodies* in *Motion* which are at Rest; and that *Body* which is once at Rest, will ever be at Rest, if it were not moved by another, or by an *Animate* incorporeal Being, (which I presume no Man will allow the *Solar Particles* to be:) for Example, they will Agitate and Rarifie *Water*; they will Actuate the Particles of Wood, Dissolve its Texture, and Reduce it into *Ashes*; they will Melt *Mettals*, and do any Thing that *Fire* will do.

Fourthly, It may be *Refracted*; but *Refraction* is *Reflection*, as they pervade a Dense Medium, as I shall shew hereafter.

Fifthly, They will add *Weight* to a *Body*, as *Glauber* says, as I do not question it to be true, since the most *Ætherial* Particles of *Fire* will do the same; (which all *Philosophers* acknowlege to be of the same Nature as these) as has bin experienced by the Great and Honourable *Boyle*: I will set down One or Two of his Experiments, to make *Fire* and *Flame* Ponderable; he says an *Ounce* of *Copper-Plates* being kept in a shallow *Crucible* in a *Cupelling Furnace* Two Hours, weighed 30 Grains more than before; but an *Ounce* of *Fileings*, in Three Hours Time were caked into a Lump, and Weighed 49 Grains more than before: Another Time, he says, Eight Ounces of *Tin* being exposed to *Calcine* in a Bolt-Head *Hermetically* sealed, the Glass flew in Pieces; but the Experiment being a Second Time

Time repeated, the Metall being suffered to cool before the Glass broke, the Weight was 23 Grains more than before, tho' the whole Calx amounted to no more than Four Scruples and Eight Grains : Note that this being done in a Glass *Hermitically* sealed, none but the most Subtile *Particles* of Fire could permeate the Glass, and be imbodyed in the Calx : He has many more Experiments, but these are sufficient to shew that the Particles darted from the Body of the Sun, are *Material*. Dr. Dickason says that he has Experimented, that *Antimony*, Calcin'd by the Rays of the Sun, has encreased in Weight : And Sir Ken. Digby says the same.

Secondly, They are of a *Spungy* Texture, and *Globular Figure* : But for the better Explication of this, we must consider the Nature, and Cause of *Springiness*, or of the *Restitution* of some Bodies, which being bent by Force, when that Force is taken off, they will return with Violence to their former Figure ; which I conceive happens, when the *Particles* which Compose the *Strata* or *Lamina*, of which the Body is constituted, are much longer than they are Broad, as in the Figure : k



Suppose, a, b, c, d, several *Lamina*, e, f, *Particles* of the Two uppermost *Lamina*, gg *Particles* of the lowest *Lamina*, now suppose a Body of

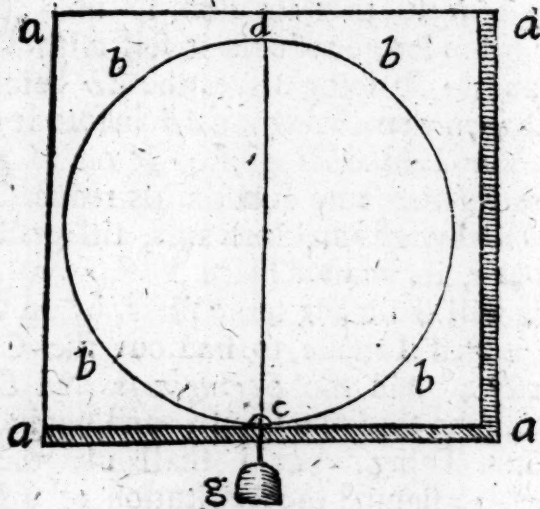
a Foot long, and half an *Inch* Thick, consisting of such *Particles* as these; as a *Cane*, and indeed all *Wood*, generally speaking, being *Springy*, visibly does; if this Body were bent by Force, so far as to bring both Ends together in a Circular Form, its manifest, that the *Particles* gg, being on the inside, will be crowded into less Room by Three *Inches*, than they Naturally require; and the *Particles* ee, on the uppermost *Strata* will be extended farther by Three *Inches*, than their Texture doth Naturally admit; for the *Diameter* of the *Circle* made by the *Particles* gg, in the lowest *Lamina*, will be shorter than the *Diameter* of the *Circle*, in the highest *Lamina* ee, by an *Inch*, and there being about Three Times the *Diameter* in the *Circumference*, the *Circle* gg, must be about Three *Inches* shorter, than the *Circle* ee, and consequently the *Particles* gg, must be crowded into a Line Three *Inches*, an One Fourth Part shorter, than they were before; and therefore these *Particles* gg in the inside, like so many little Props must bear hard upon, and endeavour to thrust off, the *Strata* that confine them, whilst the *Particles* ee, being Dislocated and Extended, do endeavour as much by drawing back, to regain their Natural Station; the *Particles* of the Body being in this Posture, so soon as the Force that bent it is removed, they will reduce the Body with Violence, the doing of which will give so brisk an Impulse upon the *Air*, as to drive it considerably before it, which therefore will not only bring it to its Natural Station, but the following *Air* pressing upon it, will carry it almost, as far beyond its Station, on the other side, and so back again; and so continue in a Vibrating Motion, till it gradually regains its wonted Station, where it remains:

mains: As suppose the same *Figure* to be a *Spring* bent so that its End *i*, may touch *h*, which being let go reduces it self with Violence to *i*, and in so doing drives the *Air* before it to *k*, and then there being no *Air* before it to resist it, the *Air* behind it presses it on to *k*, from whence for the same Reason 'tis reduced again, and so backwards and forwards, till gradually it stands at *i*, its wonted Place.

This will be made more plain, by an *Experiment*, which I made to find out the Cause of *Elasticity*; and tho' *Springiness* and *Elasticity* depend upon the same Cause, and signifies much the same Thing, yet I shall use the Word *Springy*, to signifie the Restitution of a *Body*, to its wonted *Situation*, without removing out of the Place; as when a Bow bent, is let go to its wonted Station, I shall use *Elastic*, to signifie a *Body* that by its Spring is wholly removed out of its Place, as a Tennis-Ball, from the Racket, the Solar Particles, from a Glass, &c.

To find out the Cause of *Elasticity*, I made this *Experiment*; I took a thin Piece of Whalebone, shaved it to an equal Thickness all along, but something Thinner at the Ends, that it might come near to a Circle, when both its Ends were fastened together; and when I fixt it in that Form, with a Thread thorow it, it Weighed 13 Grains, and its *Diameter* was about an Inch and $\frac{1}{4}$, and then I fixt it in a Frame, as *a a a a*, in the Figure *b b b b*, the Whalebone *c d*, the Thread fixed at *d*, and thence thorow the Centre to *c*, whence 'twas continued thorow a Hole in the Frame to the Weight *g*; when I had it in this Posture, I hanged an *Ounce* at the End of the Thread, viz. *g*, which made no alteration; I added another, which made none neither; I ad-

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ded a Third, which sunk it a little; a Fourth sunk it $\frac{1}{4}$ Part of its Diameter $d c$, as I measured by an *Instrument*, that I had for that Purpose; Seven *Ounces* sunk it $\frac{3}{4}$; $9\frac{1}{2}$ sunk it $\frac{3}{4}$; $11\frac{1}{2}$ sunk it $\frac{4}{4}$; $13\frac{1}{4}$ sunk it $\frac{1}{4}$, but then the Sides bulged out so far, that they leaned against the Frame.

By which it appears that when it was in a perfect Circle, it required a much greater *Weight* to sink it, $\frac{1}{4}$ Part of the *Diameter* then afterwards; and the Reason is, First, because the *Particles* are more crowded in that Figure, than they can be in any other; a *Circle*. being of all Figures the farthest from a *Strait Line*, their Natural Situation.

Secondly, Because in this Posture, every Particle bears equal; and the farther they recede from this Figure, the nearer they come to a *Strait Line*, their Natural Figure; and consequently bears left in that Posture, which is the Reason that the nearer the Top d , and Bottom c , of the Circle, approach to the Centre; so they grew

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Straiter, and consequently bore less, whilst those on the sides, were crowded almost beyond their strength to resist, and therefore not bearing uniformly were supprest with a less Weight; if those on the sides should be bent too far, they would either Break, or at least stand Bent; for suppose the *Particles e e e*, in the uppermost *Lamina* of the foregoing Figure, should be so far extended, as to be dislocated beyond the *Particles f f*, in the second *Lamina*; the ends of the two *Particles e*, and *f*, there closing with one another, and thereby not being capable to return to their own Places, will either stand Bent or Break.

Now suppose this, or any other *Elastic* Body, or Body made in this Figure, whose texture consists of such *Springy* Particles, as above mentioned, should be struck against any Solid Body, with so much violence, as the Impulse may bring *d*, and *c*, or the upper and lower sides, nearer to the *Centre* by $\frac{1}{4}$ part of its *Diameter*, (it being not capable of making an impression on the Solid it strikes against,) the *Restitution* of its *Springy* Particles will strike the *Air* upon its upper-side (supposing it to fall upon the Ground Perpendicular) with a *Violence* equal to above a 120 times its own Weight; for so much 4 Ounces is to 13 Grains, which it required to sink it on $\frac{1}{4}$ part of its *Diameter*; and, consequently, the Weight of the *Air* upon that part, will be lessened, in a Proportion to that *Impulse*, and then the Pressure of the *Air* under it, will drive it that way, or carry it upwards, that being the easiest way for it to move in, and will continue to carry it that way, till the *Impulse* lessening gradually, becomes less than its *Specific Gravity*, and then it descends again; the same cause will hold if it be cast side ways, as suppose against a Wall:
and

and this seems to be the cause of the Motion of *Arrows, Bullets, &c.* and indeed of all Inanimate *Bodies*, that move in any way different from their *Specific Gravities*.

And this is confirm'd by all *Experiments* of the *Hydrostatics*: which seem to depend upon the very same Laws; I shall only mention this one, and refer you to the Honourable *Boyle* for the rest. Take a Tube, put one end of it into Water, and at the other end draw off the *Air* by *Suction*, i.e. take off the *Pressure* of the External *Air* at the upper end, by separating it from, and driving it with your Tongue, and Cheeks into your Lungs, and the *Air* in the Tube will Expand it self and follow it; being *Expanded*, its *Springy* Force will be weakned; being weakned it will be unable to Resist the *Spring* of the External *Air*, which will therefore press the Water at the other end into the Tube after it, so far, till the *Air* is reduced thereby to its former *Spring*; and if you then take the lower end out of the Water, what Water is in the Tube, the *Pressure* of the External *Air* will there keep it: and if then, by a farther *Suction*, the *Air* in the Tube be more *Expanded*, the *Pressure* of the External *Air*, will press the Water higher in the Tube, there being that way less Resistance than any other: which is the same Cause, that I but now assigned, for the *Reflecting* of a Ball, or any other Elastic Body, from the Ground, Wall, &c. you may see many more Experiments in the above mentioned Honourable Author, to confirm this Truth.

From what has bin said, it appears that a Body of a Circular Figure, composed of Expansive *Springy* Particles, is most apt to *Elasticity*, or most capable of being *Reflected*, of any other; now that Body which is most Elastic, or most capable

capable of being *Reflected*, must consist of such a Texture and Figure, as is most conducing to those ends; but the *Solar Particles*, or *Æther*, are most *Elastic*, as appears by their being Reflected, that vast distance from the *Sun* to the *Moon*, or down even unto us; and from hence as far another way: for their Force is not lessened, as appears by the *Angle of Reflections*, being equal to the *Angle of Incidence*; for if it were weakned, it would fall under it, so as to make a greater *Angle*, (see *Molyneux*, pag. 181. f. 3.) therefore they consist of such a Texture, and Figure, as is most conducing to that end, viz. of Expansive *Springy Particles*, in a Circular Figure. Which was to be proved;

And if that *Circle* were filled up with lesser *Circles*, as in the Spring of a *Watch*, or Threads of a *Ball*, the Elasticity must encrease as the *Circles* do, but in a greater Proportion; for the lesser the *Circle*, the more the *Particles* are crowded, and the more *Weight* they are able to support, and are therefore more *Elastic*: from whence it follows that they are thus made up, for whatever may add to *Elasticity*, must be in them, they being most *Elastic*.

Lastly, A Body may be put into a violent Rotation Three ways; first, by its natural Temper and Figure, as the Spring of a *Watch*, when let loose, will put it self into a violent *Rotation*. Secondly, When a Body put into a violent Motion, is hindred more in one part than another, that part that is hindred, puts the whole into a *Rotation*: as when a *Globe*, or *Bowl* is thrown upon a *Flat*, or *Bowling-Green*, that part that toucheth the *Earth*, bears the *Weight* of the whole; and consequently the Impulse of the *Air* has not

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the same Force upon it, as it has upon the rest, which puts the whole into a *Rotation*; the upper Parts being easier moved, and faster impelled than the lower can follow. The 3d is, When *Matter* is put into a *Rotation* by *Elision*; as when *Steel* is put into a violent *Rotation*, by the stroak of a *Flint*, which is visible, being struck for that purpose upon *White Paper*, and ten times more expanded whilst in a *Rotation*, and Incended, than when we find it calcined thereupon.

Now the *Solar Particles*, or *Aether*, seems to Actuated all these ways; First that it has the Texture and Figure of the Spring of a Watch, or Ball, has bin proved; and consequently its Motion. 2dly, It cannot be supposed in the long Passage from the *Sun* to the *Earth*, but it must strike upon several *Particles* obliquely, which will hinder its passage more in one part than another, and consequently adds the Second cause of *Rotation*. And lastly, the stroakes it receives from the Body of the *Sun*, puts it into so violent a *Rotation* as incends it, but cannot Calcine it; it being a simple *Principle*, and consequently, if we may argue from that *Topick*, *De similibus similis est ratio*, it must give it the same Motion and Effects upon other Bodies, that *steel* incended by the stroak of a *Flint* has; which latter we manifestly see it has proportionably to its Density, and therefore we may argue the former. Which was to be proved.

From hence I shall deduce these *Corollaries*: First, That a *Solar Particle*, or *Aether*, being most *Elastic* when it falls upon a solid Body, that will not give way to it, nor be put into Motion by it, must be *Reflected*, if it fall *Perpendicular*, back again in a *Perpendicular Line*; if it falls *obliquely*, in an *Angle*, equal to the

the *Angle of Incidence*. 2dly, It being darted from the Body of the *Sun*, in a right Line, will continue in a right Line, till it falls upon a solid Body, by which 'twill be diverted, or Reflected another way; but in a Right Line, from that Body, till it meets with another, which will again Reflect it, in a different way, but still in a Right Line from it, from whence I conclude that its progressive Motion is always in a Right Line. 3dly, When they enter the Pores of any Body, their violent Rotation, and the Expansive Endeavour of their Spring to dilate, grating upon any single Particle in the Compound, will disunite it, if its adhesion be not greater, than the strength of their Spring, in that violent Rotation.

Æther agrees with *Air*, in its Natural Expansive Springiness and Elasticity; it differs from it in Subtlety and Aptitude to Rotation and Accension.

Æther agrees with *Spirit*, in its Spring, Aptitude of Rotation, and Accension; but differs from it, in that *Spirit* is not Naturally Expansive: it agrees with *Oyl*, and disagrees with it in like manner; but more it being more Dense and Fixt.

It differs from *Niter*, in its Spring, which is directly contrary; as this Expands, so that Contracts, as these act upon other Particles by Expanding, Rarifying, and Heating; so those Contracting, Condensing, and Cooling; wherefore they are contraries, and Act upon each other as such.

Æther disagrees with *Water*, in like manner; but less, as this is less Active, and more near the Nature of the Passive or Fixt; *Æther* as to its Spring, neither agrees nor disagrees with *Earth*, or *Salt*, they having no spring at all; or being

altogether *inactive*, or *fixt*, they differ only in Weight and Figure; that is, as they contain more *Matter* in less *Space*; for I conceive, that if the *Ætherial* Particles were wrapped up so as to lie in as little *Space*, as the *Fixt*, they would have the same Weight: for I take *Matter* as *Matter*, to be every where equal *quoad pondus*; *Earth* seems to be of a Figure more agreeable to *Æther*, it being more easily miscible with *Oyl* than *Salt*.

C H A P. IV.

N*itre* may be defined, to be a Principle of *Matter*, of a most Subtle, Contracting, Springy Texture; that Acts upon other Bodies, by Condensation and Cooling: From whence it follows, that there are such *Particles*, and that those Effects do not proceed from a meer Privation.

First, Because if they do depend upon meer Privation, the degree of Condensation, and Coldness, must constantly be Proportional to the degree of Privation, and consequently the *Coldness* of the *Air* must gradually Encrease every Day from the *Autumnal Equinox* to the *Winter Solstice*, and from thence Decrease to the *Vernal Equinox*, as the *Sun* is at greater distance from us, or nearer to us; but this does not hold, for we often find it warmer in *December*, than it was in *October*, as in this present Year 1702; and frequently colder in *February* and *March*, than at the *Winter Solstice*, as this has bin observed

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even to a Proverb, *As the Days begin to Lengthen so the Cold begins to Strengthen.*

2dly, Because, if the *Ætherial Particles* are intercepted in the Winter, by a Cloud, Fog, &c. it must cause a greater Degree of Coldness; there being by that means a greater *Privation* or absence of *Calorific Particles*: the contrary of which is true, for the Cloud consisting of *Watry Particles*, doth easily imbibe the *Nitrous* or *Frigorific Particles*, and hinder them in their descent; which renders the Air warmer than in the Clear Weather, which is generally Frosty; and 'tis observed that Foggy Weather presently vanishes, when Frost begins, for the *Frigorific Particles* closing with the Vapours, condenses them, and precipitates with them into that White Dew, which we call *Hoar Frost*, and so binds them up, and closes the Pores in the surface of the *Earth*, that they cannot rise again: or if they do, a Thaw succeeds. And 'tis observed these Frosts seldom last long, that come with a Frozen Fog, or Hoariness, from whence 'tis plain, that *Frost* or *Actual Cold* does not proceed from a meer *Privation*, and consequently 'tis something *Positive*; and therefore,

3dly, It must result from the Modification of some one Principle, or more, contained in the *Terraqueous Globe*, or in the *Atmosphere*: not from the *Terraqueous Globe*, for if so, it must be from *Earth*, or from some *Particle* contained therein, or from Water, or from some *Principle* in it.

First, Not from *Earth*, which being taken for that Dry Body which we daily see, and tread upon, is made up of *Earthy Particles*, properly so

called, *Sulphur*, or *Oyl*, and *Salt*: but these effects proceed from neither of those, nor from all together; for if they did, that part of *Water* in *Ponds*, &c. which is contiguous to them, would be Froze before the Surface, and those Waters that run through them, and lie deepest in the Earth, being most exposed to them, would be Froze soonest and hardest, and the deeper the harder: which is so far from it, that those Waters that are in the deepest *Wells* or *Pumps*, are observed in the hardest Frosts to come up reeking Hot. And not only the Surface of Waters are Froze, but those *Vapours* exhaled into the *Air*, are congealed into *Hail* and *Snow*; where the *Terrene*, or more Fixt parts of Matter cannot be Elevated, without a stronger Cause, than the then weak Action of the *Sun*, when these Parts of *Water* that are contiguous to the Earth are not touched with Frost.

2dly, Nor from *Water*, for in all Waters that are Froze, we always see that they begin at the Top, whereas if *Water* was the Cause of Cold, it would either be always Froze, or at least begin in the middle; and where the Waters are deepest, there they would freeze the hardest, there being more Frigorific Particles, and more united than in shallow Waters: yet deep Waters are so far from Freezing, that they preserve the Earth, that they lie upon, from being touched with Frost. when their own Surface that is contiguous to the *Air*, and the *Earth* that is not covered with *Water*, is Froze to a great depth; which argues the *Air*, to be Colder, than either *Earth* or *Water*; since it Congeals the latter, and closes up the Pores of the first. Since the Cause of Cold, is not from the whole, or any part of the *Terraque-*

ous Globe, it follows that it must proceed from the *Atmosphere*, or from some *Principle* contained therein.

The *Principles* we find in the *Atmosphere*, are either *Æther*, *Niter*, *Air*, or *Spirit*; which are the only Component *Particles* of the *Atmosphere*: besides, those Accidental *Exhalations* from the *Terraqueous Globe*, which have bin already rejected. *Æther*, *Air*, and *Spirit*, are of a Texture either directly Contrary, or much Resisting the *Frigorific* Particles; therefore it can be neither of them. Whence it follows, that the *Nitrous Particles* of the *Atmosphere*, are the true *Congeaing Principles* of Cold: From whence I shall lay down these Three *Propositions*; First, that Cold is the Effect of Positive *Frigorific Particles*. Secondly, That all *Acid Spirits* Extracted from *Vegetables*, *Minerals*, &c. are nothing but these *Aerial Acid* Particles, embodied by the *Medium* of *Water* with *Salts*. Thirdly, That these *Nitro-aerial Particles* are of a Contracting, *Springy* Texture, upon which their Power depends.

That Cold is the Effect of Positive *Fregorific Particles*, appears, First from those *Artificial Frigorific* Mixtures, viz. of *Niter*, or *Salt*, with *Snow* or *Ice*; the Two First being *Bodies* Compounded of *Air*, *Water*, and *Salts*, the *Salt* being the predominate Principle: The Two latter are *Water* Impregnate with, and Congealed by, the *Aerial Niter*, *Water* being the predominate Principle; (but with all these must be supposed to be a Mixture of some *Spirit*, tho' chiefly in *Water*,) these being mixt, the *Salt* being a Principle of great affinity, and easily miscable with *Water*, and overpowering the *Niter*, the *Saline* Particles do associate themselves with the

watry Part of *Snow*, or *Ice*; and in so doing dissociate, and set at Liberty the *Nitrous* Particles: Which then pervade the *Glass*, or *Vessel* included in them, and by associating, and combining themselves with the *Water*, and grappling with the *Spirit*, in it contained, they Congeal it into *Ice*.

That the *Congeling* of *Water*, placed in the *Frigorific* Mixture, into *Ice*, proceeds from the application of that Mixture is plain; because, it first *Freezes* in that Part, either Top or Bottom, or Sides that is Contiguous to it.

Secondly, That this is done by Particles, thus set at Liberty, appears yet; because as Mr. *Boyle* says, that *Salt* thrown upon *Ice*, made a Crackling Noise, and by a Candle-light, several Steams were observed to rise from them, as from some Hot Liquors; which shews, that there are *Particles* set at Liberty. Secondly, Because no *Salts* will promote the *Frigorific* Quality of *Snow*, so far as to enable it to *Freeze*, which quicken not its Dissolution; for then there is no more then a bare application of *Snow*, or *Salt*, which will not effect it: Thirdly, Because the *Freezing* Power of the Mixture, continue no longer, than the *Snow* and *Salt* is dissolving; for then the *Frigorific* Particles cease to rise from the Mixture. And this Mr. *Boyle* observes, where he says, ' That the *Acid Liquor* it self, being kept all Night in a Room with *Water*, was of the same Temper with it; which appeared by a *Weather-Glass* immersed in both, successively, and the *Salt* it self, being cast into *Water*, scarce made it sensibly *Colder*, nor did the *Glass* wherein this *Salt* was kept, discover any remarkable Degree of *Coldness*; and even the *Frigorific* Mixture it self, when the *Ebullition* was over, appeared not *Colder* than the common *Water*, in a Nights time.

time : So that the *Coldness* depended purely upon the departure of the *Nitro-aerial* or *Frigorific* Particles, from the *Fermenting* Liquor.

Fourthly, Because, if you Blow with a Pair of Bellows, upon a *Thermometer* over a *Frigorific* Mixture, whilst 'tis thus in *Solution*, 'twill vehemently affect it with *Cold*, and Condense the *Spirit* contained in it ; because, whilst the Mixture is in *Dissolution*, the *Frigorific* Particles arising from it, are carried with the Blast of *Wind*, from the Bellows to the Ball of the *Thermometer*, and accordingly affect it ; but if the *Frigorific* Mixture be removed, the *Wind* from the Bellows upon the *Thermometer*, shall Heat it, and Rarifie the *Spirit* contained in it. Mr. *Boyle* observes, that *Cold Winds*, receive not so much their Qualities, from the Quarter from whence they Blow, as from the Regions over which they Pass. And I have bin told by a Gentleman, whom I dare confide in, that in *Virginia*, in One Hour, when the *Wind* Blows from One Quarter, 'twill be so very Hot, that they cannot tell, how to keep themselves Cool enough : In the next, when the *Wind* Blows from Hills covered with *Snow* and *Ice*, they cannot, with all the *Cloaths* they have, keep themselves Warm. And Mr. *Boyle* tells us, that Captain *James* observed, that in *Charlton Island*, the *Southern Wind* was Coldest, which came over a *Frozen* Tract of Land. And that he was told by a Merchant, who made the Observation in *Greenland*, that he perceived a manifest access of *Cold*, upon the appearing of a Floating Piece of *Ice*. And that he was further told, to Leeward of great Banks of *Ice*, they may discover them, by the access of *Cold* Twenty Leagues. From whence 'tis manifest, that 'tis the Plenty of Positive *Frigorific* Particles in all these Winds, which

which is the Cause of *Cold*; and consequently, that there are such *Particles*. Which was to be proved.

Note, that when a Body, as suppose my Hand, or Foot, Heated, or Cooled, beyond its *Natural Temper*, as by being placed near a *Fire*, or in *Snow*; the *Fire* being removed, 'twill *Cool* again, or the *Snow*, it will again acquire its *Natural Warmth*: Here the removing of the *Fire*, is no more the Cause of my Foot's Cooling, than the removing of the *Snow* is of its Warming again; the Reason why my Foot was warm'd near the *Fire*, is because the *Air* about it, or near it, is more Impregnated with *Calorific Particles*, but when removed to a Place distant from the *Fire*, in the open *Air*, where the *Calorific Particles* do less abound, and the *Nitrous*, or *Frigorific* more; the *Nitrous Particles*, acting upon those Particles, my Foot received from the *Fire*, gradually overcome them, and drive them away, till my Foot has regained, such a Temper that is Natural to it, in such a Temperate *Air*, or *Atmosphere*. So when my Foot is removed, from that *Air*, that is contiguous to *Snow*, which is highly Impregnated with *Aerial Acid Particles*, into a Part of the *Atmosphere*, that less abounds with *Nitrous Particles*, and more with *Ætherial Particles*; it there regains its *Natural Warmth*, for the same Reason. The Second Proposition, that all *Acid Spirits*, and Liquors Extracted from *Vegetables*, *Minerals*, &c. are nothing but these *Nitrous*, or *Aerial Acid Particles*, embodied by the Medium of *Water*, with *Salt*, seems reasonable:

First, Because these *Acid Spirits*, have the very same Effects upon other Bodies, that the *Nitro-aerial Particles* have, viz. upon *Vapour*, *Water*,
Spirits,

Spirits, &c; they *Cool, Condense, and Congeal* Water or Vapour, as the *Nitro-aerial* do: they easily mingle with Water, Unite, Combine, and Coagulate it into Ice; and fly from *Spirit*, or drive it from them, and separate Water from it, as the *Aerial Acid* does. The Ice Congealed by either of them, has the same Taste, and there is the same Hostility betwixt these and *Alkaly*, as there is betwixt all *Acid Spirits*, and *Alkaly*, Proportionable to their Density; as is evident from the *Lustation* betwixt them, and the *Alkalized Ætherial* Particles, flowing from the *Sun*: and this is manifest, from the account that *Glauber* gives, of his *Concentrated Moyst Fires of Salt*, (which are *Acid Spirits*, in the 41, 42, 43. of his Second Century, where he says, ' Carry with thee a Glass full of *Moyst Fire of Salt*, and which is Congealed by the *Sal Mirabile*, and has stood some Hours in the Cold, into the Warm Stow, and hang it over the Table, by a Thread, or small Line, when your Guests are set at the Table; and when they ask you what this signifies, you may tell them, that you will for their Recreation sake, shew them some Pleasant Diversion, after they have made an End of *Eating* and *Drinking*: Upon this they will all of them have a Desire to see those *Tricks*, and ever now and then cast up their Eyes upon the Glass; but after the Glass has hanged there a *Minute*, or *Half a Minute's* Time, the Breath of the Men, that sit about it, will certainly apply it self to the Glass, and stick on the out-side of it, like Snow, and cover it all over, and thicken it more and more; in so much that in a short Time, it will have a thick and hoary Beard, all about, consisting of *Natural Ice*, and will so long keep

‘ keep it Increasing, as the *Concentrated Cold* lasts
 ‘ in the Glafs; and thus the *Nitro-aerial* Particles
 in the Night, fubfiding upon the *Vapours*, raifed
 by the *Sun* in the Day Time, Clofe with them,
 and Condenses and Congeals them upon *Hedges*,
Trees, and *Grafs*, in an hoary Beard, and thick-
 ens ’em in procefs of Time, into *Natural Ice*. In
 the 42. He fays,

‘ Command One of thefe Glaffes prepared for
 ‘ this Purpofe, to be brought to thee, and let it
 ‘ down by a Thread into a Glafs full of *Wine*,
 ‘ which being done, the *Concentrated Cold*, which
 ‘ lies in this little Glafs, which thou hangeft in
 ‘ the greater One of *Wine*, will draw to its felf
 ‘ the *Watry*, and Unprofitable Part of *Wine*,
 ‘ and change it into an infipid *Ice*; and by how
 ‘ much the longer you hold that little Glafs in
 ‘ the *Wine*, fo much the more *Water* will be
 ‘ drawn therefrom, and the *Wine* will be made
 ‘ more Generous thereby.

And thus in the long and hard *Froft*, in the
 Year 1682 it happened to *Wine*, *Ale*, and *Sider*
 with us; for then the *Nitro-aerial* Particles were
 fo Powerful, as to Attract the Watry Part of
 the *Wine*, *Ale*, or *Sider*, contained in the Vef-
 fels, they circumscribed to the out-fides, and
 there Congeal it into *Ice*, and fo Drive and *Con-*
centrate the *Spirit* in the Middle; at which
 Time I remember, People cried out, that their
Small-Beer was turned into *Ale*, and their *Ale*,
 and *Sider*, was extraordinary Strong: Particu-
 larly, I remember One Hogfhead of *Sider*, pla-
 ced under a Summer Houfe, where ’twas expofed
 to the North Wind, and hindered from the Sun,
 by an high Terras Walk; this Veffel when we
 had Plugged it, and bored a great way thorow the
Ice, we at laft came to *Sider*, which was little
 inferiour

inferiour to *Brandy*, in Strength; as many who Drank of it can testify, by being caught by it, to Admiration, before they were aware: And when it was drawn off, the remaining *Ice*, which was much the greater Part, Thawed into an *Insippid Water*.

Secondly, *Niter*, *Common-Salt*, &c. being put into *Water*, as Mr. *Boyle* observes, causes a manifest *Coldness* in it, as the *Aerial Acid* does. Thirdly, *Glauber* says, *Snow* (being Impregnated with this *Acid*,) draws a *Tincture* from *Coral*, as other *Acids* do; and which *Rain Water* will not. Fourthly, All *Acid Mineral Spirits* put upon Fixt *Niter*, and exposed to the cold *Air*, Shoot into a True *Niter*; as all *Vegetable Acid Spirits* being put upon *Salt of Tartar*, Shoot into a True *Tartar*. And Lastly, The *Caput Mortuum*, from whence *Spirits* are Extracted, being exposed to the *Air*, and kept from *Rain*, are Re-impregnated again from the *Air*, with *Spirits* of the same Kind. From whence, it seems reasonable to advance, that the *Aerial Acid* or *Niter*, is the same with the Original of all other *Acid Spirits*: and that all *Salts* differ from one another, but as they are differently mixt vvith *Terrene*, *Sulphurous*, or *Metallic Particles*, &c.

The Third Proposition, That these *Nitro-aerial Particles* are of a Contracting Springy Texture; upon vvhich their *Effects* depends, seems probable;

First, because *Contrariorum contraria est Ratio*, and therefore if the *Effects* of the *Ætherial Particles* depend upon their Expanding Springy Texture, (as has bin proved, the *Effects* of these, being truly contrary, (as has bin proved,) must depend upon their Contracting Springy Texture; for I take the Cause of *Heat*, and *Cold*,

or

or of *Quality* in General, to be such a Disposition, or Modification of Texture, in *Particles*, as determines them to have such *Operations*, upon such *Bodies*; and the result of such *Modification*, or the *Operation* it self, or rather the *Alteration*, in the Sentient that succeeds that *Operation*, to be what we call *Quality*; as *Heat*, *Cold*, &c. *Vera contrarietas propriissime dicta non reperitur nisi in Qualitatibus mutuo Activis & Passivis*; whence it follows, that if the Action of the *Ætherial* Particles, depends upon their *Expansive Spring*, the Action of these, must depend upon a *Contracting Spring*; and consequently they must have such a *Spring*.

2dly, Because such a *Spring*, is most likely to produce such *Effects*, as, *Condensation*, *Coldness*, and *Luftation*, with *Ætherial Particles*; for such a *Spring* as Contracts it self, is most likely to lay hold on any Expanded Body, it meets with in its way, as *Air*, *Vapour*, &c. to Enclose, Contract, and Confine it into less room, than it was before; which is *Condensation*: as my Hand, when grasping, is more likely to hold a Thing, than when open. And that Principle, that can thus Enclose, Contract, and Confine Matter, will at the same time, hinder the Motion of its Parts; and consequently cause *Coldness*: and if it meet with *Æther*, or Particles endued with a contrary, viz. an *Expansive Spring*, they will Close, and by a Mutual endeavour one this way, and the other another; there must be a *Luftation* betwixt 'em: and if they cannot get rid of each other, they will close together, and *Condense*, and thereby become Visible; (as the *Fumes* of *Spirit of Sal Armoniac*, and *Spirit of Salt* do, when the Mouths of the Bottles they are contain-

ed in, are put together;) or into a *Body* participating of both Natures; and so continue, till they are set at Liberty, by others of the same Kind with one of them.

Lastly, That which may be *Expanded*, is *Contracted*; for if the Parts of any Body, were stretched out to their utmost Extension, they could be Expanded no farther; but the *Acid Particles* of Niter, in *Gunpowder*, which has bin proved to be the same with the *Nitro-aerial*, may be Expanded to such a Degree, as to take up 500000 times as much Space as it did before; as Mr. Boyle observes, who says ' that *half a Grain* of *Gunpowder*, being exploded under a Vessel, whose *Basis* was Eight Inches, and its *Altitude* 20, and its *Figure*, such as was more capacious than a *Cone* of that size; the Exploded *Gunpowder*, was observed to fill the whole Cavity of the Vessel, as to Sense, and successively issued out of the Upper Orifice, for $\frac{1}{3}$ of an Hour: So that the *Diameter* of it being Two Inches, many *Miriads* of visible Corpuscles, must be conceived to throng out in so long a time, as they crowded out one after another. But to make a kind of Estimate, of the *Expansion* of this Substance; we filled the Vessel full of Water, and found that the *Weight* of it amounted to 320000 *half Grains*, and if we suppose the *Specific Gravity* of *Gunpowder*, to be as much again, as that of *Water*, we may probably guess the *Smoak*, to possess 500000 times the space, that the *Gunpowder* did.

And it can scarce be conceived, that *Sulphur*, and *Niter*, being put into a Rotation by *Fire*, should shatter and tear each other to that Degree, unless they were each of them, endued with a Spring,

Spring, of a contrary Determination to each other; by which means, in their conflict they may grind one another to pieces, with an unspeakable Celerity, and Violence.

Niter differs from *Æther*, in its Active Part, viz. in its *Spring*; for which reason, they are directly contrary: it agrees with *Water*, both in *Spring*, and *Figure*; for which reason, there is a great Similitude, or Sympathy betwixt them: *Earth* and *Salt*, having no *Spring*, its indifferent to either; but by *Figure*, it seems much easier miscible with, and of greater Affinity to, the latter: The *Air*, has a manifest *Elastic Spring*, yet in its violent Comprest Condition, being incapable of Exerting it, 'tis indifferent to it: It flies *Spirit* and *Oyl*, they having great Affinity with *Æther*.

CHAP. V.

AIR may be defined, to be a *Principle* of *Matter*, of an *Expansive*, Springy Texture; but more Dense, and weak than *Æther*; and its Violent Comprest Condition, not near so capable of Exerting its *Spring*: from whence it follows, 1st, That it is of an *Expansive*, Springy Texture. 2^{dly}, That it is in a State of violent Compression.

First, That it has an *Expansive Springy Texture*, Mr. Boyle has proved by many Experiments; I shall relate One or Two of them, and refer you to that Glorious Author, for the rest:

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in One ply'd, he says, that 'Having conveyed
 ' into the *Receiver*, a *Lamb's Bladder* well dried,
 ' and limber, and half full of *Air*; the Cover
 ' being Luted on, and the Pump being set at
 ' Work. We observed, that as the *Air* in the *Re-*
 ' *ceiver*, was gradually *Exhausted*, that in the
 ' *Bladder*, was accordingly *Expanded*; till the
 ' *Receiver* being near-fully *Exhausted*, the *Blad-*
 ' *der* seem'd very much Distended with the in-
 ' cluded *Air*. And to confirm our Guess, that the
 ' *Expansion* of the *Air* in the *Bladder*, proceeded
 ' from the weakned Pressure of the Ambient *Air*;
 ' we generally let in the External *Air*, and found
 ' that the *Bladder*, by Degrees subsided, till it
 ' came as empty as before. But one thing re-
 ' markable in this Experiment; that the more
 ' the *Receiver* was Exhausted, the more sensibly
 ' the *Bladder* was Distended. Now left in this
 ' Experiment, it should be doubted, whether the
 ' Distention of the *Bladder* did not proceed from
 ' the *Fibres* of the *Bladder*, returning of their
 ' own accord, to their Natural Extension, upon
 ' the removal of the External *Air*; we put in
 ' two empty *Bladders*, along with the former,
 ' and found them very little Distended, upon the
 ' Exuction of the *Air*.

The like *Phenomena* were afforded, by repeat-
 ing the Experiment, with a *Bladder*, which was
 half empty, and half filled with *Air*; the empty
 part, being parted from that, that contained the
Air, by a Ligature. In another place, He
 says,

' Having put a Quantity of *Water* into a Bottle,
 and Immersed the end of a Glass Tube, a little
 below the Surface of it, which was about Three
 Foot long; the Interstices betwixt the Neck of
 the Bottle, and the Pipe, were filled with Ce-
 E ment,

ment, and the whole was convey'd into a *Receiver*; and because the Pipe was too long, to be contained in the *Receiver*, another made of White Glass, was cemented to the former, to the middle of whose Cavity, the upper end of the Pipe extended: so that the Motion of the Rising Water, had more room to move in, when the Pump was set on work. Where'twas observable, That upon the first Exuction, the Pressure of the External *Air* being taken off, that contained in the Bottle, Expanded it self, so powerfully, as to raise the Water in the Tube with such Force, that it flew, violently, against the top of the *Receiver*; but as the *Air* in the Bottle, was leasurely Expanded, and came nearer to an *Equilibrium*, with that in the *Receiver*, the Spring of that in the *Bottle*, being less powerful, the Water in the Tube, gradually ceased in its ascent; unless the Pressure of the External *Air*, was taken off, by a fresh Exuction. And we observed, that when the *Air*, was in a great measure Exhausted, the upper *Receiver* being taken off; the External *Air*, pressed the Water quite down to the bottom of the Tube: and several Bubbles, getting thro' the Water, joined themselves with the *Air* in the Bottle. But what was more strange, was, that when the *Receiver* had bin taken off a considerable time, several Bubbles of *Air*, continued to make their way thro' the Water; as if the Spring of the included *Air*, being before expanded, could not be brought again, to its former state of Compression: but like a *Ballance*, put in Motion, continued several successive *Vibrations*, resisting each Impress of the *Atmosphere*.

In another place, He says: ' To shew the Durableness of the *Air's Spring*; leaving a small Portion of *Air*, in the folds of a *Lambs Bladder*, whose neck was closely tied; it was enclosed in another Vessel, and convey'd into our *Pneumatic Engin*: and when the *Receiver* was Exhausted, the Expanded *Air* distended the *Bladder*, so that it filled the whole Cavity of the Vessel; by whose sides it was guarded from the Pressure of the External *Air*: so that the Expanded *Air*, kept the *Bladder* Distended for two Years. He goes on, and finds by one Experiment, that *Air* may be so far Expanded, as to take up 8000 times, as much Space as it did before. By another 10000. By another 30000 times as much. And to conclude, He says, If we compare the utmost Degrees of Condensation and Rarefaction together, the same Portion of *Air*, may possess 520000 times the Space at one time, that it did at another. *Boulton's Abstract. Vol. 2. pag. 258.*

From which Experiments, its manifest, that it has an *Expansive Spring*; and that that Body, which would Expand it self, to the Degrees above mentioned, if that Weight was taken off, which confines it, must be Comprest; and in a state of Violence whilst so confined, and kept from Expanding it self, viz. by the Weight of the Incumbent Atmosphere: which, by reason of its being piled up, to so vast an Height, tho' it seems light, in respect to those other Bodies here below; yet must have weight to Bend, and exceedingly to Compress the Spring of that *Air* it lies upon. For suppose a Cube of *Air*, Three inches square, to Weigh One Grain; a Pillar of *Air*, a Foot long, will Weigh Four Grains; and of a Yard, Twelve Grains; and of 1000 Yards long,

long, 12000 *Grains*: this being continued many *Miles*, will amount to a Weight, sufficient to Bend, and violently to compress, a *Spring* stronger, than we can conceive that of *Air's* to be. And that a Cube of *Air* Three *Inches* Square, will Weigh a *Grain*, Mr. *Boyle*, has proved by this Experiment: ' He took a Lamb's *Bladder* whose ' Cavity, exceeded not Two third Parts of a *Pint*, ' and counterpoised it, in a very nice *Ballance*, ' which being pricked, upon the Avolition of the ' *Air* in it contained, lost a *Grain* and $\frac{1}{2}$ of what ' it Weighed before. From whence He argues (as I do,) that if it has weight, it follows that a Column of *Air*, of many *Miles* high, leaning on those below, is enough to Compress and Bend their *Springs*; as when *Wool*, is heaped up to a considerable heighth, that which lies under is Comprest by that which lies upon it; and if upon a Parcel of *Air*, so vast a Quantity lies, no wonder, that upon the removal of that pressure, it powerfully Expands: which yet seems to be more Comprest, by the *Spring* of the *Ætherial* Particles, which would Expand themselves farther, if not confined by the *Solid Firmament*.

Air, by its *Spring* and Texture, is of greatest Affinity with *Æther*; but by reason of its violent State, or comprest Condition, it is not so capable of Exerting its Expansive Power, as to render it irreconcilable to either, the *Aerial Niter*, *Oyl*, *Spirit*, or *Water*.

C H A P. VI.

BY *Spirit*, I do not understand, those that are commonly call'd *Acid*, or *Urinous Spirits*, which I take to be Compounds; but such a one, as consists of such Inflamable *Particles*, as we commonly see in *Spirit of Wine*: so that *Spirit*, may be defined, to be a *Principle of Matter*, which, tho' it has Naturally no *Expansive Spring*, yet it is very apt to be incended, and easily miscible with *Water*, and meanly with *Oyl*, but very difficultly with *Niter*, or *Salt*.

It is a *Principle*; because it consists of Homogenous *Particles*, which are dispersed throughout the *Universe*; as appears, because it may be Extracted from all *Bodies*, that are capable of *Fermentation*; by which 'tis disengaged from the Combinations of the other *Principles*, *Water* having a greater Similitude to it, than *Oyl*, and so separates it in *Fermentation*. That 'tis dispersed throughout the *Watry Element*, with which it has great Affinity, seems probable: 1st, Because it gushes out upon the opening of those Vessels of *Water*, that have bin *Fermented* at Sea, as appears, by its being incended if any *Flame* be applied to it. 2^{dly}, Because the Honourable *Boyle* has found something in Bubbles of *Ice*, different from *Air*; as appears, by its not Expanding its self in *Vacuo*; which likewise shews, that it has Naturally no *Expansive Spring*. From whence, and from its Globular Figure, its Congruity with *Water*, seems chiefly to result.

3dly, That it may be Extracted, from all *Vegetables*, is evident from every Days Practice : and *Glauber* says, from *Animals*, and *Minerals* ; and is usually seen from the *Urine* of the first. That 'tis easily miscible with *Water*, and difficultly with the *Aerial-niter*, and *Salt*, has bin already shew'd, and wants no Probation : it being so visible, in the making of *Tincture of Tartar*, and *Spirit of Wine*, that will *Fire Gunpowder* ; tho' if there be the least drop of *Water* in the *Spirit*, it mixes with the *Niter*, and hinders the Effect.

C H A P. VII.

OYL may be defined, to be a *Principle*, which, tho' it has no *Expansive Spring*, yet is very Inflamable, and Immiscible with *Water* ; it has Affinity with *Spirit*, *Æther*, *Earth* ; and a Reluctancy to the *Nitrous Particles*, and *Salt*. It is a *Principle*, because it consists of Homogenous *Principles*, and is Extracted from ; and consequently in *Animals*, *Vegetables*, and *Minerals*. But the Honourable, and ever Renowned *Boyle*, objects, and says ; *Chymical Principles*, of which *Oyl* is one, are Transmutable ; and that the *Grand Chymical Supposition* will not hold, viz. That, whatever *Similar Body*, is obtained by the Operation of *Fire*, from a *Concreat* committed to *Distillation* ; it was formerly *Præ-existent* in it : to prove which, He makes this Experiment.

Having Distilled (says He) a Pound of *Essential Oyl* of *Aniseeds*, in a *Retort*, in a *Sand Furnace*, Thirty six times successively : We observed these following *Phænomena*: *First*, A Black Substance, like *Pitch*, was left behind every Distillation ; but oftentimes, a subsequent Distillation, yielded more than a *Præcedent* had done ; allowing for the quantity of *Oyl* lost in so many *Cohobations*. *2dly*, Towards the latter end, the *Oyl* was so *Fixt*, that it required a strong Fire to raise it. *3dly*, It ascended not like an *Homogenous Body*, but a less *Volatile Oyl*, succeeded the first that came over ; and after that, came a different from that which preceded it. And, *4thly*, Besides the Black, several other Substances, were produced in the Operation ; as a *Waterish Phlegm*, which after some Distillations, rising into Bubbles ; they had such a conflict with the *Oyl*, as often to endanger, and once to break the *Retort*. *5thly*, And besides these, it likewise afforded a Substance, taken by some to be a *Volatile Salt*, it ascended to the top of the Vessel, where it appeared in a dry form, like *Short Needles*, and was dissolved in its *Spirituos Phlegm* : but whether it was a *Volatile Salt*, or not, I was inclined to doubt ; because it would subside to the bottom in *Water*, and not melt there : and was fusible at the *Flame* of a *Taper*, like *Wax* ; and when kindled, would afford a *Yellow Flame*, and partly, more intensely Blew, than that of *Rectified Spirit of Wine* ; but it was apt enough to go out of it self ; yet I suspected it somewhat of kin to a *Sal. Volat. Oleos* : such as *Camphir*, since it rises in a dry Form, with a strong Fire ; and may be dissolved in *Spirit of Wine*, without discolouring it, as *Camphir*, dissolved in

Oyl of Vitriol, gives it a Reddish Brown, so
 did this: As also, the Solution of it, being
 mixt with common Water, a dry Body pre-
 sently Emerged; and One Thing more remar-
 kable was, that it glittered much, like *Flowers*
 of *Benzoin*. Sixthly, Besides these Substances,
 it likewise yielded us a little *Spirit*, which
 came over with the *Phlegm*, and would not
 mingle with the *Oyl*; and as it was more Fixt
 than the *Oyl*, or *Phlegm*, so it rose later than
 they; and not only required a stronger Degree
 of Fire, but rose in White Fumes, as several
Fixed Spirits are wont to do: It would like-
 wise dissolve *Coral*, and Cause a great Ebulli-
 tion, with Noise, and Bubbles, whether pour-
 ed upon the Fixed Salt of *Tartar*, or the Uri-
 nous, and Volatile Salt of *Sal. Armoniac*.

This Experiment, answering what I intended
 by it; I shall make the following Reflections
 upon it. First, That a Substance looked upon
 to be *Homogenous*, and a *Chymical Principle*,
 may afford very different Substances, when
 acted upon by Fire; for the Black *Caput*
Mortuum, was very difficultly fused, in so
 strong a Fire, as made the Retort, and Sand a-
 bout it Red Hot; it would be undissolved in
Rectified Spirit of Wine, thro' which, the *Oyl*
 would presently be diffused, without the help
 of Heat: but when the Liquor was Boiled, it
 gave it a Tincture; and of this *Caput Mor-*
tuum, in the whole Process, we obtained half
 the Weight of the whole *Oyl*; and from hence
 we may learn how precarious *Chymical Analysis*
 is; since it is not yet determined, after what
 number of Distillations, is to be accounted a
Principle. Secondly, from some *Phænomena* in the
 preceding Experiment, it appears that Fire, is

not

not the Free Genuine Instrument of the Analysis of Bodies ; since it does not barely Extricate, and Separate, the several Similar Substances, from the *Oyl of Aniseeds*, which is looked upon to be the *Sulphurous Principle* of the *Concreta*, from which we obtained Three or Four several Substances.

Thirdly, From hence likewise we may infer, that the *Fire*, does not separate, but variously Compound, and alter the Parts of a Body exposed to its Action : Since the *Oyl* yielded a Fixed, and *Earthy* Powder, a *Phlegm*, a *Spirituos* Liquor, and a Dry *Sublimate*, which have divers Qualities, like those obtained from Compound Substance : Whence it appears probable, that *Chymical Principles*, are *Transmutable*. Here I shall take Notice, that *Acid*, and *Aqueous* Substances, how different soever they be from Pure *Oyl*, may be produced from it, by the Action of the *Fire*, since the *Phlegm* would dissolve *Coral*, and would Ferment with *Tartar*, and *Spirit of Wine* ; yet the greatest Part of the *Phlegm*, was Aqueous, and different from the Essential *Oyl*, whose Purity makes it wholly Inflamable. The Quantity of *Phlegm* obtained from the *Oyl*, amounted to Two Ounces, and Six Drachms. And here we may have Reason to Question, whether it be necessary to suppose, with the *Chymists*, that *Nature* had bin obliged, to make Provision of great Quantities of Primordial, and Simple Bodies ; and that She is not Solicitous, to mix them altogether, for the composing of a Body. And from what has bin said, it may be inferr'd, that the *Præ-existences* of such Substances, must be made out some other way, than the bare

' bare Operation of Fire ; since the *Grand Chymical* Supposition, will not hold, viz. *That what ever similar Body, is obtained by the operation of Fire, from a Concreat committed to Distillation; it was formerly Præ-existent in it.*

In Answer to which, tho' I do assert, that there are such *Principles* ; yet I do not say, that we can obtain any of them, embodied Pure, and Free from all Mixture with any of the other. But that the Principles of One Sort, may retain some of those, that they have so much Similitude to, as to be easily miscible with ; and that those may retain others, with which they have the like Similitude, tho' more different from the former ; and these in like manner a Fourth Sort, differing from all the Rest. For this, I take to be the *Origine of Composition* ; and thus the *Oily Particles*, Distilled from any *Concreat*, may retain some of the *Spirituos*, with which they have some Affinity ; especially when they are not Extricated from them, by a precedent Fermentation, with *Watry Particles*, which being more Simular to the *Spirituos*, will separate them from the *Oily* as they seldom are, when *Oyles* are designed to be Extracted ; and the *Spirituos*, being easily miscible with *Watry Particles*, may retain some of them ; and they being easily miscible with *Acid* and *Saline Particles*, may likewise retain some of these ; and yet the *Oyl*, may be so predominant, as that they may be Inflamable together ; and as to Sense, seem to be but One *Homogenous* Body, and thus they are in *Amber, Jet, Sulphur, &c.* which notwithstanding their Inflammability, are evidently mixt with other Substances. But yet it does not follow, because they cannot, or are difficulty obtained Pure, and Free from Mixture ; that there are

no such *Principles*, or that they are *Transmutable*. Because these may, by repeated Distillations, be separated from them ; for different Particles, that have Affinity with each other, may be so united, as not to be separated by *Fire* : and the Reason may be, because they will fly away together from it, before it can Exert its Power upon them : And thus we see, they do in *Spirit of Sal Armoniac* ; and not only in *Urinous*, but in all *Acid Spirits*, and *Volatile Salts*. And we know that *Spirit of Sal Armoniac*, is a Compound, consisting of *Salt* and *Water* ; because we mixt 'em in the *Retort*, and can separate them again, by pouring upon them an *Acid*, as we can the *Acid*, or *Nitrous* Particles, in an *Acid Spirit*, from *Water*, by pouring them upon Filings of *Steel*, &c. (where the *Acid* Precipitates, and Closes with the Mass, (and leaves the *Water* insipid,) to which it has greater Affinity ; it being Compounded chiefly of *Nitrous*, and *Sulphurous* Particles, as appears by the Flashing of its Subtle Filings, when exposed to the Flame of a Taper.) and if to these, *i. e.* to the *Spirit of Sal Armoniac*, we add *Spirit of Wine*, we shall have a *Sal Volat. Oleos* : Consisting of *Spirit*, *Water*, and *Salt*, inseparable by *Fire*. And if to these, we add *Cinamon Bark*, or any other *Aromatic Spice*, we shall have a *Sal Volat. Oleos* : consisting of *Spirit*, *Salt*, *Water* and *Oyl* ; as is manifest by its retaining the *Genuine Odour* of the *Bark* : And as the *Fire* separates this Latter from the *Bark*, so it unites it in the *Spirit*. So that we grant, that *Fire*, has not only a Power to separate Compounds, but likewise, to Unite *Principles* : And this it seems to perform, in the Hatching of a Chick ; for 'tis that gentle Digestive Heat of the Hen, &c. which

which both Actuates, Separates, and Divides the *Principles* in the *Egg* ; and Disposes, Contextes, and Unites them, into *Flesh, Blood, and Bones* in the *Chick* ; without which there would be no such Effect. And 'tis the violent Action of *Fire*, that Agitates, Disposes, Contextes, and Unites *Ashes and Sand*, into that Durable Body of *Glass*. And I cannot conceive, but the *Fiery Particles*, may so Embarefs, wrap up, and by Mixing, may confine the *Sulphurous Particles* of the *Oyl*, into that *Pitchy Empyreuma*, in the abovementioned Experiment ; by only altering their Form, and by Uniting with them, as it will with *Sugar* and the *Juice of Herbs*, in the making of *Syrups*, &c. when they are said to be Burnt.

And since it is plain, that the *Particles*. in the above mentioned *Urinous Spirits*, will be so firmly United, and Contexted, by the Affinity, or Similitude they have with each other, or at most by the Actions of the *Fire*, in a bare Distillation, as to evade the Power of separating them : I cannot conceive, but the same *Principles*, may better be United in the Compound, (in which they are, by Nature so nicely Mixed, as to seem One *Homogenous Body*) than to be perfectly Separated, in the First Distillation by *Fire*.

And if so, First, that Substance looked upon to be *Homogenous*, may still be a *Chymical Principle* : tho it invisibly contains those other Substances, mentioned by the Honourable Author, as the *Water* in the last mentioned *Sal Volat. Oleos* : is a Principle of the *Aristotelians*, and *Moderns* ; notwithstanding it invisibly contains *Spirit, Oyl, and Salt* in it : and it may be the Action of the *Fiery Particles*, involving themselves

selves with the *Oyle*, that at the same time rushes, or presses out those other Substances, when it involves, and incloses these, in that Black *Caput Mortuum*; which may be so combined by the gradual *Fire*, in frequent Distillations, as at last to undergo a considerable Degree of *Fire*, without Flying, or Flashing. For those Things that are combining or hardened by *Fire*, will require a much stronger *Degree* of the same, to Separate or Dissolve them: And tho' it might be so modified by *Fire*, as to remain undissolved in *Redified Spirit of Wine*, yet when Boiled, it gave it a *Tincture*; which shews that 'twas still *Sulphurous*, and that 'twas possible to disunite 'em, and reduce them to their *Pristine* Nature. And to me, it is no Wonder, that the *Action* of the *Fire*, should at length, by reiterated Operations, not only change half, but all the *Oyle Particles*, into that Black *Caput Mortuum*: Since there seems to be the same Reason, for the last as for the first. That it ascended, not like an Homogenous Body, seems to make for me; since I acknowledge it, not purely to be such: a less *Volatile Oyl* Succeeding the First, seems to argue the First was mixt with *Spirit*.

2dly. That *Fire* is the True, and Genuine Instrument of the *Analysis of Bodies*, seems evident from the separating of those very Substances, after which there was no farther *Analysis*.

3dly, That the *Fire* does variously Compound, and alter, the Parts of a Body Exposed to its Action, I shall readily grant: Since I take this to be the chief Cause of Digesting, and Uniting Homogenous, and Heterogenous Particles in a Compound; and that it may be allowed, that
from

from *Oyl of Aniseeds*, may be distilled an Earthy Powder, (as he calls it) a *Phlegm*, a *Spirituuous Liquor*, and a *Dry Substance*, (as being contained in it,) which have divers Qualities, like those obtained from compound Substances. Yet that *Fire*, should have Power to Transmute *Oyl* into *Water*, seems to me very improbable; for if it has Power to Transmute, any Part of that which is really *Oyl*, into *Water*, &c. it has Power to Transmute the whole into *Water*; there being no greater Reluctancy in One Part, of that which is the same, than there is in another; which I presume the Author would not grant: This Experiment seeming to prove the contrary, and that a *Phlegm*, a *Spirituuous Liquor*, a *Dry Substance*, and Lastly an *Acid Spirit* in White Fumes, should come over one another, is no Wonder to me, who grant them to be there, and allow the most *Volatile*, and easiest separable, to come over First; and thus the *Phlegm* being most *Volatile*, and very repugnant to the Fiery Particle fly first: A *Volatile Spirit* consisting of Two *Volatile Principles*, viz. A *Volatile Salt*, and *Water*, both which have a repugnancy with *Oyl*, are ready to Fly next: And a *Dry Substance*, or *Sublimate*, consisting of Two *Volatile Principles*, viz. a *Volatile Salt*, and a *Spirituuous Oyl*, as is manifest from its being dissolvable in its own *Spirituuous Liquor*; but would subside to the bottom of *Water*, and not melt there, and was fusible to the Flame of a Taper, like Wax, and when Kindled would afford a Yellow Flame, and partly more intently Blew, than the Flame of Rectified Spirit of Wine, and a Solution of it dropt in *Water*, would Emerge in a Dry Body like *Camphir*; all which, shew that it was a Body mixt with *Saline*, but more
Sul-

Sulphurous Particles, which latter having a greater Affinity with *Oyl*, than the Two former Substances, was for that Reason, with more difficulty separated from it, and therefore succeeded the Two former in Distillation. The *Acid Spirit*, seems to be strongly combined with a fixt *Principle*, viz. *Salt*, with which it has so much similitude, as not to be separated without a strong *Fire*; and therefore ascends last, (as the *Spirits* from those *Salts* do, as we see in *Sea Salt*, *Alom*, *Vitriol*, &c.) in *White Fumes*, which shews them to be of the same Tribe, and consequently to ascend from the same Associates: which meeting with an *Alkaly sublimed* in the Top of the Retort, would undoubtedly make a Luctation with it there, as well as with *Urinous Spirits*, *Coral*, or *Lixivious Salts* afterwards. This indeed shews that our great Author, has observed, that an *Acid Spirit*, may be Extracted from *Oyls* in general, even from *Oyle of Turpentine*, or *Oyl of Hearts-Horn*, (as he shews in the next Page;) the Last of which, is an *Animal*: and consequently any Thing may be expected from *Oyl of Blood*, as is from it. Which may decide the Controversie betwixt Two Learned Men, Dr. *Chirac*, Dr. *Vieussened*; which is, which of them discovered an *Acid Spirit*, from *Oyl of Blood* first. Since our famous Author observed it in the above mentioned *Oyles*, before either of them: which might inform them, it was in *Blood* also, tho' 'tis possible, that neither of them had it from either of the other; but from their own Labour, and Observations

From what has bin said, it may be inferr'd; First, That Principles are not Transmutable: from whence it follows, that there must be a great Fund of each Sort, sufficient for the various

rious Mixture, and Composition of *Animals, Vegetables, and Minerals* thorowout the *Universe*.
 2dly, That Various Substances, may be contained in One seeming *Homogenous Particle*, from which it has it Denomination: And consequently that, that great Supposition of the *Chymists*, may still hold good, *That whatever Similar Body, is obtained by the Operation of Fire, from a Concreat committed to Distillation; it was formerly Præ-existent in it.* And this our Ingenious Author grants, in the End of his *Sceptical Chymist*, where He says, 'yet it is not denied, but 'that divers *Mineral Bodies*, may be Resolved 'into a *Saline*, a *Sulphurous*, and a *Mercurial Part*; and that most *Animal, and Vegetable Substances*, may be divided into *Salt, Phlegm, Spirit, Oyl, and Earth.* And tho' these *Principles*, 'be not purely void of all Mixture, they may 'without any great inconveniency, be stiled *Elements*, and bear the Name of those Substances, 'that they most resemble, and which are manifestly predominant in them: Nor will it be 'denied, but that very often the *Medicinal Vertues* of a mixt Body, may reside in some One 'of those *Principles*.

C H A P. VIII.

WA T E R may be defined, to be a Congeries of Dense *Principles*, endued with such a Contracted *Spring*, that it seems to Emulate a *Solid*; or to be Inactive altogether, as *Earth, and Salt*: and neither Inflammable nor easily

fly Miscible with Oyl, or Sulphur: but may by a LuEtation, when confined with its contrary, be violently Expanded, from whence it follows. First, That 'tis a Principle; and this is agreed, first from the *Universality*, it making up great part of the *Terraqueous Globe*: and being mixt with the *Air*, and in all *Animals*, *Vegetables*, and *Minerals*, as they are Naturally Compounded; as is evident, from their Analysis, in every Days Practice.

2dly, From its *Homogeneity*, it seeming to be every where the same, and tho' it is capable of being *Rarified*, by the Action of the *Fire* or *Æther*; yet it is not by that means Transmuted or Destroyed: for it is as Natural to it, to be Expanded, or have its *Figure* altered, in the LuEtation with its Contrary, as to Contract it self, when at Liberty, and to regain it, or be again reduced, by striking against a Solid, or by Meeting, Adhering and Uniting there, with those of its own kind; as we see every Day, in *Distillations*, *Clouds*, *Rain*, &c.

But the Great *Boyle* objects, in his *Experiments* concerning *Forms* and *Qualities*; and says, it may be Transmuted, or Turned into *Earth*; which he endeavours to confirm, by this following Experiment. Having, says He, 'in a Glass Vessel Distilled fair *Water*, and several times, Redistilled it again; we found, that after every *Distillation* there was a considerable quantity of *White Earth*, remaining at the bottom of the Vessel: which was more plentifully afforded in the latter *Distillations*, than the first; and therefore we had greater Reason to believe it could be nothing else, but a certain quantity of *Water*, turned into *Earth*, which afforded the

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following *Phænomena* : First, Being put into a
Microscope, in the *Sun Beams*, it appeared to
 consist of Parts exceeding fine ; which were as
 fine in the *Microscope* as *Hair Powder* usually is
 to the Eye, yet not in the least *Transparent*.
 2dly, Being mixed with *Water*, it turned it in-
 to a Whitish Colour, as the Powder of *White*
Marble, usually does ; yet being settled in the
 bottom, it remained *Undissolved*. 3dly, After
 after it had been a considerable time, in a red
 hot *Crucible*, it was neither Diminished in
 Quantity, nor did it in the least Smoak. 4thly,
 It exceeded *Water* in Weight, so as to be equal
 to twice its Bulk of *Common Water* : being al-
 most as heavy as *Wood Ashes*, freed from their
Salts ; which to its Bulk of *Water*, is as 1 to
 2½, which does not much come short of the
 Weight of *White Glass*, which is twice and half
 Heavier than its Bulk of *Water*. So that from
 these *Phænomena*, we had reason to term the
 forementioned White Substance, *Earth* : Con-
 sidering likewise, its *Fixedness*, and other *Quali-
 ties*.

To which, I answer, that *Fire*, having an *Ex-
 pansive Spring* ; and *Water* a *Contracting Spring*,
 and being confined, may so Trample, and Close
 with each other, as to twist themselves together,
 like a *Hair* in making a *Fishing-Line* : being
 twisted strongly, different ways, at both ends,
 and let go in the middle, by a Mutual *Lu-
 xation* with each other, will Entangle and Twist them-
 selves, into that Form, we see them in the *Line* :
 so 'tis possible that these Two *Principles*, striving
 with each other, may so Entangle and Twist them-
 selves together, like the *Hair*, as to loose the
Force of both their *Springs* ; and also their *Globu-
 lar Forms*, whilst in that Posture. And consi-

quent

quently loose the State of *Fluidity* and *Perspicuity*, which depend upon it (as I shall shew hereafter;) and a Subsidy to the Bottom. But this is not the *Transmuting* of one, but the *Uniting* of two *Principles* in a Compound: and this Luſtation of the *Ætherial* Particles may be one Cause, of the variety of *Juices*, Generated in the Vessels of *Plants*, that are Nourished only by *Water*, and very probably, is the Cause of *Acid*, and *Alcaly's*, cloſing in a Salsum, which are not Transmuted, but for the time United; and may be again Extricated, and Reduced from each other; as possibly the former. For I conceive, 'tis the Nature of *Fire*, after it has separated the *Heterogeneous*, to Close, and Unite with the *Homogeneous*. And this, I the rather suspect, because it always imparts its *Alkaline* Nature; as in this Case, the *Learned Author*, seems to prove. For, he says, *Oyl of Vitriol* poured upon this *Powder*, would Corrode it: and that by an Effusion of *Spirit of Salt*, there was raised a considerable Ferment; as when *Spirit of Salt* is put upon *Lapis Stellaris*: and grants the other, in his *Produceableness* of *Chymical Principles*, in these Words. 'I know not, but that the *Fire*, uniting with some Parts of *Water*, may Form some Invisible Concretions, which sticking to one another, may Form Aggregates of Powder; as in the Precipitation of *Quicksilver*, without Addition, the *Mercurial* Particles being associated by *Fire*, began to Form very Minute Concretions, which encrease more and more, till they Form a Red Powder. And I have observed, that *Alcohol of Wine*, being Boyled in a Bolt-head, *Hermetically* sealed, would afford a considerable Quantity of a Chalky Substance, as I have obtained from *Water*.

Here, that *Ingenious Author*, grants, that the Particles of *Fire*, may be so United with those of *Water*, as to Form a Powder; as they do in the *Red Precipitate*, from *Quicksilver*, without Addition, which is not Transmuted, but may be again reduced into Running *Mercury*. And such an Alteration as this, must be allow'd; or otherwise the Principles, could not be so duly mixt in the Compound, as to seem, as they do in many of them, but one *Homogenous Substance*.

2dly, That they have a *Contracting Spring*, is proved by the same Arguments, that I have proved the *Nitro-aerial Particles* to have One. To which may be added their *Aptitude*, to adhere to the *Asperities* of any Body, they strike against, whose Particles being *Smooth*, and *Globular*, (as I shall shew, when I discourse of *Elauidity*:) it can scarce be conceived, they should do, if they had not such a *Spring*, as would lay hold of, and hang by those *Asperities*; as we see they do, in that which we call *Wetness*.

3dly, That they are so *Contracted*, or *Wrapped up*, as to Emulate a *Solid*, or a *Particle* in its Natural State, altogether *Unactive*; seems probable: *First*, From its *Gravity*. 2dly, Because no Weight, or Violence will force it into less Space; as appears by several Experiments, made by the *Academie Del Cimento*.

I shall only mention this one; Page 117: and refer to the Book. 'We ordered a thin large Vessel of Silver to be Cast, and fill'd it with Water, cooled very well with Ice, and Screwed the Cover on, with a very Close Screw; then we began to Hammer the Vessel gently, every where, and the battered Silver, (which being

' so little Ductile, did not at all Thin, and Di-
 ' stend it self, as Refined *Gold*, *Lead*, and other
 ' soft *Metals* do,) Lessened and Comprest, the
 ' Inward Capacity of the Vessel, by Degrees :
 ' yet the *Water*, for all this, suffered not the least
 ' *Compression* ; for at every Stroak we perceived it
 ' to Sweat thro' the Vessel, at all the little Pores
 ' of the Metal ; as *Quicksilver*, when prest with
 ' a piece of Leather, spurts thro' in little Drops.

Lastly, That it is capable of being *Expanded*
 violently, by a Luctation with its contrary ;
 seems manifest, by this Accident. I know one
 that was making Bullets ; who to gain time, and
 to cool the Moulds sooner, put them into Wa-
 ter : but upon the pouring in of the next Melted
 Lead, it was drove out again like Shot, by a
 sudden *Expansion* of the Water, with an Explo-
 sion, and Noise, not inferior to that of *Gunpow-*
der, fired in a Pistol ; but that *Water* is capable
 of *Rarification*, and not at all *Inflamable*, nor ea-
 sily *Miscible* with *Oyl*, are things so well known,
 that they need no Probation.

Its *Relata*, or the *Sympathy*, and *Antipathy*,
 that it has with the other *Principles*, has bin
 shew'd already above. Mr. *Boyle*, makes the
 like *Objections* against *Spirit* ; but that which
 answers these, answers those.

C H A P. IX.

THE Two *Inactive Principles*, viz. *Earth*, and *Salt*, having no *Spring* at all, can have no other *Similitude* or *Dissimilitude* with the other *Principles*, or with each other, than what results from *Figure*, *Size*, or *Weight*: and tho' by these they may be exceeding *Different*; yet the Excellent *Dr. Grew*, reduces those that differ in *Figure*, or *Superficies*, to these three *Generals*, (in his *Explication of the Nature of Mixture.*) viz. Such as can *Touch* but in a *Point*, or in some small *Part*; as when Two *Particles* meet, that are *Globular*, or otherwise *Glibbous*. 2dly, To such as can *Touch* in a *Plain*, as in the *Conjunction* of the *Sides* of *Triangular*, *Quadrangular*, or otherwise *Flat Particles*. 3dly, To such as can *Touch* in a *Concave*, as when one *Part* of a *Particle* is admitted into the *Concave*, or *Hole* of another; as a *Spigot* is into the *Hole* of a *Foſet*. Those differ in *Size*, which take up *More* or *Leſs Space*; and those differ only as they are *Bigger* or *Leſs*; tho' the *Degrees* may be *Indefinite*. That is, *Heavieſt*, that contains most *Matter* in *Leaſt Room*; and these likewise can differ, but as *Lighter*, and *Heavier*, tho' the *Degrees* may be *Innumerable*. So that these, having no *Spring*, can have no *Motion*, but what results from their *Weight*, which will be only toward the *Centre*; as the *Active Particles*, by their *Spring*, extricate themselves from them. As for *Volatile Salts*, I conceive there is none *Positively*, or any otherwise such; than as the *Tortoise*, that

is carried in the Talons of the *Eagle*, may be said to be *Volatile*. For, I conceive, all *Volatile Urinous Salts*, are compounded of *Saline*, and *Sulphurous Particles*; which being long digested together, and by that means closely United to each other; the *Fire*, easier than it can *Separate* them, will *Sublime* them both together; the *Volatile*, or *Sulphurous* being supposed to be Predominant, and therefore carrying the *Fixt* along with them. And I conceive, 'tis by this means, that the *Saline* puts on the Nature of the *Sulphurous*: and so becomes *Volatile Alkaly*, or *Urinous Salt*, capable of making a Luctation with *Acid*, which it would not otherwise do.

And that *Volatile Alkaly Salts*, do Participate of *Sulphur*, seems to be confirmed by these Three Reasons: First, Because they are generally Distilled from such Bodies, in which *Sulphur* is a Predominant Principle, and with which they have bin long Digested: as from *Soot*, *Urine*, *Blood*, &c. by which, we may conceive them so closely Context, and United, as above. 2dly, Because, being mixt with a *Solution of Mercury Sublimata*, there will result a *White Precipitate*; whilst *Fixt Alkaly's*, that are free from *Sulphurs*, cause a *Yellow*. 3dly, Because, *Niter* when melted alone in a Crucible, will not take *Fire* of it self; yet upon an Addition of *Sal Armoniac*, it flashes vehemently: which shews, that the *Sal Armoniac* contains a *Sulphur*, by which the *Niter* is excited, to such *Explosions*. To which may be added, what the Honourable *Boyle*, says upon the *Mechanical Origin, and Production of Volatility*. viz. That by copious, and proper Additaments, which may be much more disposed for *Avolition*, than is necessary for their own *Volatility*; and whose Particles are of such Figure, that

are apt to fasten to the Body to be Elevated,
 and by frequent *Cohobations*, not only *Salts*, but
 all *Metals* may be brought over in *Distillation*.
 Not by being positively in themselves *Volatile*,
 but by being held by the *Volatile*, seem to be such,
 being carried along with them.

C H A P. X.

NOW having searched out, and established
 the Number of the *Principles*, viz. *Eight*:
 of each of which, I conceive there may be an E-
 qual Quantity *quo ad pondus*; and to take up an
 Equal space in the *Chaos*. And having shewn
 that those that are *Similar*, do easily Associate,
 and Unite with each other; and that there is a
 Luctation, and Difficulty of *Union*, betwixt those
 that are *Heterogenious*, and *Dissimilar*.

Let us suppose then, (as in the *Creation*) all
 those *Particles* both *Active*, *Passive*, and *Mean*,
 of which the *Universe* is now composed, in that
 Order we see it; to be confusedly jumbled toge-
 ther in one disordered Lump or Mass: in which
Fluid, and *Springy* Particles, are so Intricately
 Entangled with the *Grave*, that they are not able
 to exert their *Motions*, but lie at as much Ease in
 the *Centre*, as the *Surface*; and the *Grave*, and
Fixt, as easy in the *Surface*, as at the *Centre*.
 We cannot but conceive, there being six of the
Active, *Fluid* Principles, to two of the *Fixt*, e-
 qually mingled together; but the *Body* that re-
 sults from these, thus mixt, must put on the
Form of a very Tenacious *Fluid*. Which some of
 the

the *Ancients*, have very properly called *Ille*, from *ἰλος limus*, *ab ἰλος vel ἰλός pro ἰλύνω inuolvo*, by which is properly signified, a very *Tenacious Fluid*, or *Viscous Slime*, (*ἐκ ὕδατος ἰλος κάτῃστε*) like the *White* of an *Egg*, or *Birdlime*; which some describe thus, *Ille est præmordiale omnium rerum Principium*: others thus, *Ille est Materia Cæli & Terræ in formis quæ primum ex nihilo facta est*: others call it *chaos biatus tenebræ*, a *χαίω*, *hisco*, by which they signifie a *Dark gaping Gulph*, or *Abyss*, or something most obscure, and define it to be *Rudis indiagestaq; moles in qua omnia erunt confusa & commixta*; others call it, *Materiam siue Massam confusam ab initio hiantem*. All which probably were taken from, or at least do very well agree with, that description of *Moses*, in the *First Chapter of Genesis*, where he says,

In the Beginning, God made Heaven, and Earth; and the Earth was without Form, and Void: and Darknes was upon the Face of the Deep. And in this, all the abovementioned, seem to be contained; *In the Beginning, God made Heaven, and Earth*, i. e. He made that *Mass*, consisting of those different *Particles*, out of which the *Heaven*, and *Earth* were *Formed*, and do now consist; all Things being *Formed* out of like *Particles*, by which they are conserved. 2dly, Because the *Elastic Fluid* mobile *Particles*, were much greater in Bulk, than the *Grave*, and *Fixt*; it would *Superficially* seem to be all *Water*, or *Fluid*. 3dly, Because *Elastic* mobile *Particles*, were so combined with the *Fixt*, that they could not exert their *Motions*; *Darknes was upon the Face of the Deep*: for where there is no *Motion*, there can be no *Light*. 4thly, Because, the different *Particles*, were confusedly *Entangled* therein, with each other; 'twas a *Tenacious Substance*, without *Form*.

Form. And, *ſtily*, *Void* ; becauſe under theſe Circumſtances, it was incapable of it ſelf, to produce either *Living Creatures*, or *Plants* ; or to be Adorned with any Order.

But as the *Heat* flowing from the Body of the *Hen*, in Incubation ; puts the *Particles* contained in the *Egg* in *Motion* : ſo we may conceive the *Particles*, thus contained in the *Ylle*, or *Chaos*, when the *Spirit of God* Moved upon the Face of the *Waters*, by the *Divine Will*, and *Command* were *Actuated*, and *Moved*, *i. e.* thoſe contrary *Elaſtic Particles*, being incloſed with the *Fixed* in the *Chaos*, began to ſtrive amongſt, or within themſelves, that is to exert their *Expansive Powers* ; which becauſe they were commanded, could never Reſt, till each one by Extricating it ſelf, had obtained its appointed *Place*.

From whence it will follow, that the moſt *Subtle* of the *Ætherial Particles*, would firſt Extricate themſelves; being capable, by reaſon of their *Minuteness*, to force thro' a leſs Space, and having a ſtronger *Spring*, in Proportion to their *Bulks*, to make their Paſſage, and from thence to *Ascend* by the Protruſion of others, to the *Fiſt* and *Higheſt Place* : and to conſtitute the *Waters above the Firmament*. Which by reaſon of their exceeding *Minuteness*, *Elaſticity*, and *Activity*, may be, very properly, called *Light* ; either as they are the *Material Cauſes*, or becauſe *Light* is nothing but *Subtle Matter*, Violently Agitated ; and poſſibly may be there Reſerved, and Separated from the Inferiour : as being a fit *Matter*, for the *Reſpiration* of a *Spiritualized* and *Glorified Body* in the *Habitation* of the *Bleſſed*.

After theſe, the *Operation*, or *Efficacy* of the *Divine Word*, continuing ; the next moſt *Subtle* *Ætherial Particles*, would Extricate themſelves;
in

in doing of which, we may suppose, they would meet with some *Nitrous Particles* of exceeding subtlety; and by making a Luctation with them, would drive them away also, and Ascend in like manner, to the next Highest Place. And as these by their *Spring*, Extricate themselves, and by Expanding, Ascend higher; so those that have no *Spring*, falling into their Places, and by being depressed by these, must necessarily sink Lower: those that are next most subtle, follows these; and so on, till all the *Springy Principles*, have Extricated themselves, and by Expanding, and Dilating themselves, have forced the foremost to an inconceivable Distance. And the Grave and Fixed, being as it were the *Feces*, or *Caput Mortuum*, of all the rest, are subsided to the *Centre*, or Middle of all the rest: as the Breath, or Fume of a Furnace, disposes it self to the Figure of a Room; so the lighter parts of the *Chaos*, circularly to its Determined Bounds. Which done, the *Evening*, and the *Morning* were the *First Day*; the *Evening*, of *Darkness*, *Mixture*, and *Confusion*; and the *Morning*, of *Separation*, and *Production*: when the *Active Particles* causing Light, were separated from the *Inactive*, hindering Light, and causing *Shadow*, or *Darkness*.

From whence it follows, that God Created the *Chaos*, or Seed-plot, containing all the above mentioned Differing *Particles*, of *Nothing*: and placed it in an *Infinite Empty Space*, or *Vacuum*, that is, where there was nothing to hinder the *Particles* contained in the *Chaos*, from Expanding themselves *ad infinitum*; if they had been capable of it: for all *Created Matter*, being contained in the *Chaos*, there could be nothing *Material*, beyond its utmost Limits. From whence it will follow,

That

That, when the *Ætherial Expansive Particles*, had Extricated themselves, from the Combining Particles, in which they were Involved, and Intangled with in the *Chaos* ; there was nothing to hinder them, but that they might Expand themselves to their utmost Bonds, so as to be totally at Ease, or Void of all *Compression*. In which Condition, they must necessarily take up more Room; for if this Inferiour *Air*, which of all the *Expansive Particles*, is most Gross, and least capable of Dilating it self, may be so far *Expanded*, as to take up 520000 times more Space at one time, than another, as has been proved by *Experiments* made by the Honourable *R. Boyle*, for that purpose (in which probably 'twas neither *Expanded*, nor *condensed*, to its utmost Degree;) those *Springy Particles*, which are gradually more subtle, and more Expansive than each other, as they are more Distant from these, to many Millions of *Miles*, must take up many Millions of times more Room, than they did in the *Chaos*. From whence, 2dly, 'Tis manifest, that tho' they take up abundantly more Room, yet they do not do it Adequately, but as their Parts recede from each other, so there is many *Vacuties* betwixt them. As a Ball of *Iron*, being beaten, and made into the Form of a *Watch Spring*, and suffered to Expand it self, will take up abundantly more Room, than when it was in a *Ball* : because its Parts receding from each other, leave great Spaces betwixt 'em ; tho' it Adequately, *i. e.* Totally fills no more Space, than when it was in a *Ball* : as may be Experimented, by puting it into a Vessel of *Water*, which it will Raife no higher, than when it was in a *Ball*. From whence it follows, that, that *Space* that is filled up with
Particles

Particles thus Expanded, cannot be *Adequate Plenum*.

3dly, Those most subtle, Light, and most *Expansive Elastic Particles*, that first Extricated themselves from the *Chaos*, were thrust forward by those that succeeded, 'till they came to their appointed *Place*. Hence it follows, that none of them are *Positively Light*, or do *Naturally Ascend*, any farther than they are forced, (beyond the *Expansion* of their *Springs*) but are (beyond this) in a *State of Force*; being kept at that Distance by the *Protrusion* of the *Inferiour Particles*, they rest upon: so that all of them, even the most *Subtle*, have a *Natural Tendency* to the *Centre*, or some *Degree of Gravitation*.

Hence, Lastly, That as soon as the *First*, had obtained their appointed *Place*; all the intermediate *Spaces* were filled up with *Particles* of various *Degrees*, one more *Gross* than another; even from the *Waters* above the *Firmament*, down to the *Centre*. This *Separation* of the *Active Springy Particles*, from the *Grave* and *Fixt*; and the *Placing* them *Regularly*, the *Heaviest*, viz. the *Earth*, and *Water* in the *Centre*; next the *Air*; and so on to the *Firmament*, or that *Solid Orb*, that divides that *Celestial Uniform Waters* or *Fluid*, in the *Habitation of the Blessed*. From those *Heterogenous*, *Miscible Particles* in its *Concave*; was the *Work of the First Day*.

C H A P. XI.

AND the Making of this *Solid Orb*, or *Firmament στενωμα Firmamentum, vel Solidum quid, στεγος Solidus, vers. 8 and 9. was the Work of the Second Day.*

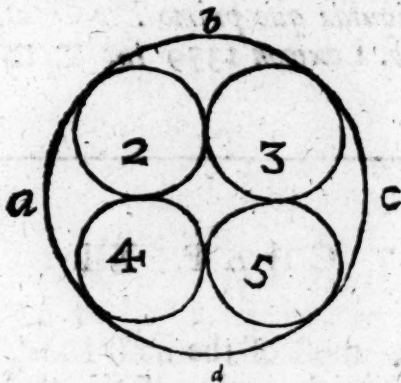
And here, I conceive the *Word Firmament*, may be taken; First, either for that *Solid Orb*, in which the *Fixed Stars* are placed, and are as I conceive, so many *Protuberances*, or *Hemispheres*, in the *Concave* of that *Orb*, of the same Substances with the *Orb*, (with which they are contiguous, or at least do adhere,) which is made, as may be supposed, of the *Grossest Part* of those *Celestial Particles*, above the *Firmament*; which being *Minuter*, and more *Subtle* than any below, may be laid *Closser* and *Finer* together: and therefore being *United* into a *Solid*, is more capable, as having *lesser Pores*, of setting *Bounds*, to all the *Inferiour Particles*: And is therefore a proper *Instrument*, to divide the *Waters*, or those *Pure Fluid Incorruptible Particles*, that are above that *Firmament*, in which the *Sun, Moon*, and other *Lights* are placed, from the *Waters* below the *Firmament*. Which *Orb* may be called a *Firmament*, not only because 'tis *Solid*; but because it *Fixes*, or *Determines* the *Bounds*, of all that *Fluid Matter* betwixt it, and the *Earth*. 'Tis called *εργαζομενος* *finis terminus, ut sit limes & terminus, inferiorum a superioris*, as *Aristotle* will have it; but

but *עֲרֹפָה* & *שָׁמַיִם*, the First signifying it Substance, the Second its Use ; are both *Emphatically* exprest in the Hebrew Word *Rakiah* which *Moses* uses : which properly signifies *Solidum Expansum*, a Solid Body so Expanded, as to divide the Waters from the Waters, or to set Bounds to the Springs of the Fluid it contains. Or else 2^{ly}, It may be taken for all that Fluid Matter, betwixt it and Earth, in which the Sun, and Moon are placed, and Fowles Fly. Which may be called a Firmament, *quia firmat Terram*, because it fixes, and Supports the Earth in the Centre. Or 3^{dly}, it may be taken for that Solid Orb, and all that Fluid Matter both together, and so it divides those pure Incorruptible Waters, that are above it, from those most Corruptible, that are below it, which are the Seas, &c. And that which divides Waters from Waters, or Fluid from Fluid, (for 'tis in this respect, that the *Ætherial* Particles bear an Analogie with Waters,) must be Solid ; because there is no Mean, that will divide Fluid from Fluid, but Solid ; & *vox maim aqua*, *Genesi* ist vers. 6. *sumitur pro tota illa materia liquida que primo Die Creatæ est*, *Sand. Pagrim. Heb. Lexicon* 1379 sub *מים*.

C H A P. XII.

NOW, most of the most Fluid, and Springy Particles, viz. *Æther*, *Niter*, *Air*, *Spirit*, being separated, and some of them protruded to a vast Distance, from the Grave and Fixt, viz. *Earth* and *Water*, *Oyl* and *Salt* ; we may

may conceive the *Earth*, or *Terraqueous Globe* begun to grow Dry, in respect of its former Essence, and to tend to the *Production of a Compound* : that is the *Grave and Fixed Particles*, began to be abundantly Predominant, and became again Tenacious, by Reason of their Number. So that those that remained of the *Springy*, could not Extricate themselves, without carrying them along also. And in this Posture, we may conceive, that the *Springy Particles*, flowing from the *Centre* to the *Surface*, would be variously Entangled with the *Fixt* in their Passage; and by their Luctation would form various Compositions of them, into various *Bodies* : Which as by their struggling, they approach the *Surface*, would Shoot out into *Vegtables*. As for Example, suppose several *Globules* or *Bubbles* of different Compositions meeting in the *Surface*, should there be included in One larger, and all of them Participating in some degree of all the Particles, but chiefly of One, 2, or 3, &c. as in the Figure; suppose the *Globules* 2, 3, 4, 5, to



be included in the Globe *a b c d*, in the *Surface* of the *Earth* : and in the *Globule* 2, to be a Composition of *Æther*, *Niter*, *Air* ; *Air* predominating

dominating : In 3, to be a Composition of *Water, Niter, Earth*; *Water* predominating : In 4, *Water, Oyl, Earth*, and *Water*, being of a nearer Mixture, but *Water* (as being a *Vehicle* to all the rest) Predominating. I say such like Mixtures, being contained in several *Globules*, in the *Globe a b c d*, a *Fermentation*, or Luctation of *Principles* with each other, in each *Globule*, will Expand each in particular; and consequently, that which contains them all. Which because it can neither be towards *a, d, c*, the *Earth* in those Parts Resisting of it, it must be towards *b*, into the *Air*, there being least Resistance that way. But as it extends towards *b*, to the sides *a, c*, by reason of the United Pressure, of the yet soft *Earth* and *Atmosphere*, will close together, and cause the whole to Shoot into a *Plant*: which by reason of its *Tenderness*, and the Pressure of the *Atmosphere*, will be in a *Taper*, or *Conical Form*. For the United Forces of the contending *Particles* being stronger in the *Centre*, will there resist the *Atmosphere* with the greatest Violence; but as the *Body* gives way to them, and is farther Extended, so their Springs will be weakened: and consequently the Pressure of the *Atmosphere*, will there have more Power over them, and force them into less Room, or closer together, and the farther the closer. So that all the *Globules*, that contain such a Composition, as is in the *Bubble z*, will, being thus extended, form *Air Vessels*, or Long and Slender *Tubes*, or *Pipes*, thro' which the *Air* may have passage; those in 3, *Lymphaducts*; those in 4, *Milk Vessels*; in 5, *Sap Vessels*, &c.

And as *Particles*, or Compositions of the same kind, in their Endeavour for Liberty, strike against, or meet with those several Vessels, and

there find a Passage Adequate to them ; and a Composition of the same Nature with them, they will easily mix with it, thrust that forwards, and Extend and Augment the Whole : But because it cannot be supposed, that these Compositions, should be so exactly Made, but that they will carry some Cruder *Particles* along with them, which being there separated at their very Entrance by Percolation, will stick there, and form the *Root* ; Consisting of such *Spongy Particles*, that will easily imbibe such Liquors, or Fluids, that they were before Mixed with, and are there separated from.

From the various *Combinations*, or Mixtures of these *Particles*, in Conjugation, Proportion, and Location, Result the Three Great Generals, viz. *Animals*, *Vegitables*, and *Minerals*. In the First of which, such *Salts*, that have been long Digested, and closely United with *Oily Particles*, and by that means obtaining the Nature of a *Volatile Alkaly* seem to abound. In the Second *Acid*, or *Nitrous*, and *Watry Particles*. And in the Third, *Saline*, and *Fixt*.

Which latter, the Sacred Writer makes no mention of, may probably be conceived, to be Generated this Day : For we must suppose, that the greatest Part of the *Springy Particles*, were separated from the *Chaos*, and the remaining being mostly *Dense*, and *Ponderous*, were grown Tenacious (as above,) especially towards its *Surface*. And as the *Inactive Terrene Particles*, by their Weight would Subside to the *Centre* ; so meeting in their way, with the *Saline*, and *Aqueous*, they would Precipitate the former, and Press the latter, being *Light* and *Fluid*, towards the *Surface*, which in their Passage would meet with more of the same Kind : with which being

being *Similar*, they would Unite. And First, By their *Fluidity* would creep betwixt, and dissolve the Combinations of the *Terrene Particles*. And then 2dly, Being assisted by the Pressure of the *Terrene*, as they descended towards the *Centre*, would by this means Form themselves *Chanel*s, to all Parts of the *Surface*, which they would enlarge, as they encreased in Quantity.

Now whilst this was done, we must suppose, that there were vast Quantities of the *Sulphurous* or *Oily Particles*, lodged in many Places, especially near the *Surface*, they being lighter and glabrous; and as the *Saline*, and *Watry Particles* fell upon these, in their Passage to the *Superficies*, by a Luëtarion with these Dissimilar, and *Bituminous Particles*, they would be Rarified into *Vapours*. Which Vapours being impatient of being pent, they would Exert their Forces in vast Explosions, and make the then Yielding and Tenacious *Earth*, give Way to them, (as the Fluid Metall, in making of *Glass* does, to the Breath of the *Artificer*,) and Form vast *Cavities* in it, and at the same time Raise it much higher upon the *Surface*; which would make such *Irregularities*, as we call *Hills*, and *Mountains*. And these *Cavities* being filled with *Water*, that would Subside into them, make the *Repositaries* of the *Great Deep*.

This Account of the *Formation* of the *Mountains*, cannot be thought strange; since we have in Account in latter Ages, not only of vast *Chasmes*, made in the *Earth*, but even of New *Hills* on the *Dry Land*; and New *Islands* cast up in the *Sea*, by the violent *Explosions*, of such *Subterraneous Vapours*, (the *Vulcanian Islands* in the *Meditaraean Sea*, are said to be of this sort.) Tho' it cannot be supposed, this is the only

only Cause of all *Hills*, and *Irregularities* on the Face of the Earth; but only of those *High Mountains*, that so vastly exceed others: For as there are different Soils, in its *Surface*, so some being more *Porous* than others, would Dry sooner, and that which *Crusts* soonest would remain Highest.

2dly, As the *Waters* Flowed to the Surface of the *Earth*, so by reason of their *Fluidity*; they would be Directed to that Part of it, where were fewest of the abovementioned *Irregularities*, or *Hills*: and in their Passage, would make themselves *Chanel*s, indented in and out, as we see the little Streams, that are prest out of the Subsiding Mud, in a *Pool* new drawn will do; till they meet altogether, and by their *Volubility* Form that Bed, in that tender *Earth*, in which that vast Quantity, we call the *Seas*, are laid.

When not only the *Springy Particles*, had Extricated themselves, but the *Watry* were collected into the *Seas*, and the *Dry Land* appeared, covered with *Vegetables*: We may suppose the *Earth* being *Dry*, was grown *Porous*; by reason of the *Interstices* and *Passages*, made by the *Elastic Springy Particles*, as they issued out of the *Surface*. And therefore,

3dly. The *Saline*, and *Sulphurous Particles*, being still the same, would still Act upon each other. (This I presume being the only *Central Fire*, that is in *Nature*.) and by their *Luclations* still raise such *Subterraneous Vapours*: which now when the *Earth* was become *Dry*, would not have the same *Effects*, as to raise *Hills* and *Mountains*, (except upon Extraordinary occasions.)

ons.) But the *Earth* being now Pervious, they would Dissipate, as they were Generated, and pass thro' its Pores to the Surface; and in their Passage, if they meet with such *Terrene Mixtures*, as were fit for *Mineral Concretions*; they would combine with them, and Precipitate into *Metalline Oars*, or *Stony Rocks*, according to the Purity, or Impurity of the *Saline*, and *Sulphurious Principles*; and different Percolations thro' Finer or Courser Earth. And possibly it may be for this reason, that there are but few *Hills*, but what are Repleat with *Minerals*.

The *Saline*, and *Sulphurious Vapours*, I take to be the True *Demogorgon* of the *Philosophers*, or *Grandfather* of all the *Heathen Gods*, i. e. *Mettals*; as is manifest in many of their Writings, particularly in *Glauber*, *Sandivogious*, and *Lenotes*: And is apparent, from the *Sulphurious Vapours*, and *Odours* that arise from the Attrition of *Stones*, and *Oars*; and the Fusion of *Mettals*. And when they advise us to reduce *Mettals* to their *First Principles*; they mean no more, than into such *Vapours*: Which when you have done, you need no more, but by divers *Percolations*, and *Subtilizations*, to get their specifying Parts for the *Meliorating* of *Mettals*. For we see there is no other difference betwixt the *Crude Juice* in the *Roots of Vegetables*, and the *Finest Mixture* in their *Flowers*, and *Seeds*, Or betwixt the *Chile* in the *Stomach*, and the *Highest or Most Subtle Spirits* in an *Animal*, than what proceeds from *Purification*, and *Subtilization*; which are performed by *Percolation*, and *Digestion*. And since *Nature* is *Uniform* in all Her *Actions*; we may judge the same in *Minerals*: And then, if there be any such Thing, as the *Melioration*, or *Transmutations* of *Mettals*; the way is Plain and Easie.

C H A P. XIII.

BUT we will leave this at present, and proceed to the *Fourth Days Work*; in which God made *Lights in the Firmament of Heaven*, or these *Great Bodies*, or *Wandering Stars*, which we commonly call *Planets*; together with their *Satellites*: which are to *Divide the Day from the Nights*, and to be for *Signs and for Seasons, and for Days, and for Years*. First, I shall consider their *Substances*; 2dly, their *Figures*; 3dly, their *Position*, and *Orbs*; 4thly, their *Numbers*; 5thly, their *Difference*; and 6thly, their *Motions*.

And First, as to their *Substances*; I conceive them to be made by the *Divine Architect*, of the same *Particles* (like the *Firmament*.) with their own *Orbs*; and by him *Condensed, Compacted, and United* into *Vast Solid Bodies*: Polished like *Metallic Speculums*, *Fixt*, and *Imperspicuous*. These Qualifications makes them more *Apt*, (as we see by our *Looking-Glasses*.) for the *Reflecting* of *Ætherial Particles*: And because the *Planets*, do *Reflect* them farther than any other *Bodies*; therefore those that are most *Luminous*, or *Reflect* them farthest, must have these Qualifications in the Most Eminent Degrees.

2dly, Their *Figure* appears to be *Spherical*; considering their *Magnitude*: But like the *Earth*, admitting of *Inequalities*, as it does of *Hills and Valleys*; as seems evident by their *Darkened Places*. Neither must they be understood, to be altogether

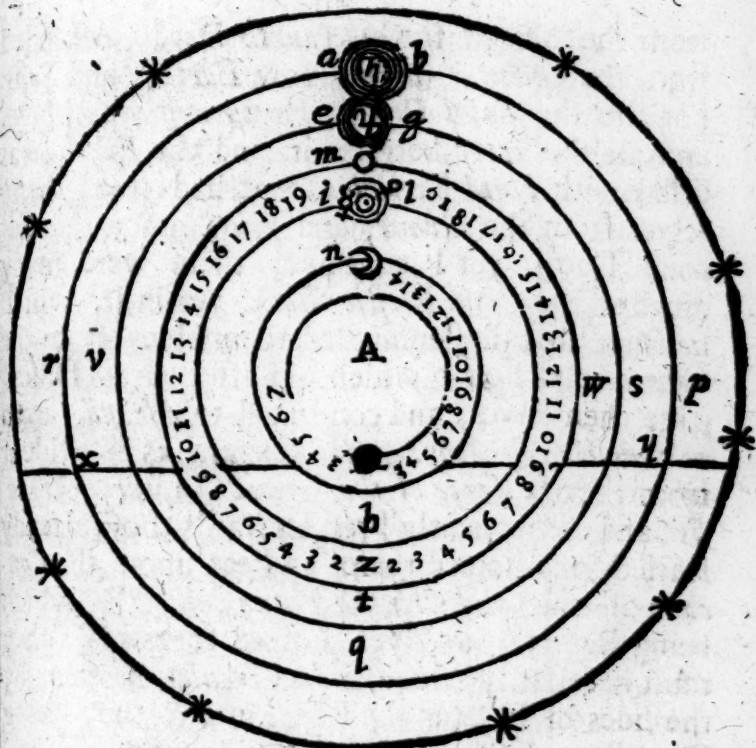
altogether *Solid*, that is, every *Particle* contained in the *Figure*, must not be supposed to be the same as the *Whole*, or *Out-sides*; for then they, by Reason of their *Gravity*, (*i. e.*) they containing more *Matter* in less *Space*, the *Expansion* of their *Particles* being hindered, by being United into a *Solid* or *Firm Body*,) would *Descend Perpendicularly*: But that their *Inner-Parts*, are more *Porous*, or *Concave* filled with the *Lighter Air*, or *Æther* of the *Superiour Orb*, like a *Ship* upon the *Sea*, which tho' some *Parts* of it, are *Heavier* than *Water*; yet its *Concave*, being filled with *Air*; and therefore much *Lighter* than *Water*, the *Whole* being taken together, and considered as one *Body*, is *Lighter* than such a *Bulk of Water*, (and therefore *Swims*) the *Air* contained in its *Pores* or *Cavity*, lessening more, than the *Great Guns*, or *Solid Parts* of the *Ship*, exceeds the *Weight of Water*. In like manner, the *Planets*, with their *Satellites*, for the same *Reason*, *Float* upon their determined *Orbs*; when Posited thereupon, as they were on the *Fourth Day*. On which I conceive,

3dly, They were Placed according to the *Ptolemaic Hypothesis*; in such a Degree of the *Ætherial Fluid*, as was *Adequate* to their *Gravities*, One under the other, as first *Saturn*, next *Jupiter*, then *Mars*, then the *Sun*, then the *Moon*, and the *Earth* in the *Centre of All*, about which they move. As is evident from hence, because they may not be in *Conjunction* with each other, but likewise in *Opposition*: and that the *Moon* is *Lowest*, is plain; because it makes the *Greatest Parallax*, of any *Planet*, the *Sun* the *Greatest* next, *Mars* next it, &c. Moreover 'tis manifest, that *Planet*, to whose *Orb*, that *Common*

Distance of the Centre, has the Least Proportion, that has the Greater Circuit about the Earth; And so the Orb of Jupiter Encompasses that of Mars; and for the same Reason, is contained within the Orb of Saturn, the Convex of the Lower Orb, filling up the Concave of the Higher; the Convex of Jupiter, filling up the Concave of Saturn; the Convex of Mars, that of Jupiter, &c.

The Inferiour Orb, as for Example, the Orb of the Sun being as much Grosser, than the next Orb above, viz. the Orb of Mars, as Water is Grosser, than Air, or Earth than Water; and as much Lighter than the Orb below, or the Orb of Luna, as Denser than the other, & sic de ceteris. Which we must necessarily conclude from the Continued Rarification of the Ætherial Particles, in the Distance betwixt each Orb; for, *Omnis Air quo propior est Terris hoc spissior, quemadmodum in Aqua & omni Humore fex una est, ita in Aere spississima quæq; desidunt*, as Seneca argues, but then it will follow,

4thly, That there are but Five Planets; Mercury and Venus Numbred among the Satellites; and consequently, but so many Orbs. - By Orb, I understand that Fluid Matter, on which the Planets Move, i. e. all that Fluid Matter, betwixt the Earth, and the Moon, I take to be the Orb of the Moon; and all that Fluid Matter, betwixt the Moon and the Sun, to be the Orb of the Sun, and its Satellites; and so of Mars, Jupiter, Saturn, as in the Figure: That Fluid Matter, betwixt Saturn and the Fixt Stars, I take to be peculiar to those Stars; tho' perhaps there may be many other Planets, betwixt Saturn and that Solid Orb, unknown to us.



5thly, the *Planets* being in this *Position*, by Reason of the *Density* of the *Fluid Matter*, on which they *Float* ; they cannot *Descend Perpendicularly*, by Reason of the *Weight* of their *Own Bodies* ; they cannot *Ascend*, but *Press the Orb downwards* ; which, being *Composed of Springy Particles*, *Resists* with a *Counter Pressure Upwards* : Which *Resistance*, together with the *Aptness* of their *Figures*, causeth *Motion*. Which, because it can neither be *Upwards*, nor *Downwards*, must be *Circular* ; especially, when the *Way* was *Delineated* to them, by the *Current of Ætherial Particles*. The *Whole Ætherial Fluid*, being put into *Circulation*, by the *Rare Particles*, that yet, *i. e.* when the *Lights* were *Made*, and *Placed* upon their *Orbs*, viz. from

from the *Second* to the *Fourth Day*. Ascended from the *Chaos* ; or the now *Earth*, and *Seas*. For tho' the *Solid Orb*, or *Firmament* was Made, and all the *Space* betwixt it, and the *Earth*, was filled with *Fluid Particles*, that had freed themselves from the *Grave*, and *Fixt*, upon the *Second Day* ; yet I conceive, there were many more of the same *Elastic Stock*, yet in it, which had not then Dissentangled themselves from the *Grave*, and *Fixt* : which did afterwards Dissengage themselves, and continued to *Ascend*, even to the *Fourth Day*, and longer, as is evident from the *Six Verse of the Second Chapter of Genesis* ; and consequently Prest forwards those already Raised, and Forced them, to Beat upon the *Concave* of the *Solid Orb*, or *Firmament* : By which being *Resisted*, and yet Forced forwards, they must necessarily Move, in a *Circular Motion*, by the sides of it. (as the *Fumes* in a *Retort*, being Beat down by the *Glass*, turn over the *Helm*.) By which, I conceive all the Contiguous, or Adjacent *Fluids*, would be brought into *Circulations*, and the *Whole Space*, or *Cavity* of the *Solid Orb*, in which they were contained, would be so Crowded by the Continued *Emanations* from the *Chaos*, as to undergo a Great Degree of *Compression* ; (tho' not so as to admit of no Point of *Vacuum* amongst them ; for then it would necessarily follow, that there could be no *Motion*, either of Them, or of any Thing in Them,) but to undergo such a Degree of *Compression* ; and so fill up the *Cavity* of this *Orb*, as to bear strongly from the *Centre*, upon every Part of it : So that if they had more Room, they would expand themselves abundantly farther.

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Being under these Circumstances, those *Particles* that *Circulate* by the sides of it, must necessarily carry it along also.

First, Because there are many *Hemispherical Protuberances*, viz. the *Stars* in its *Cavity*, which in their *Circulation*, they must *Press* strongly upon.

2dly, Because, They bear strongly upon Every Part of it: so that they can scarce *Move* without Moving it also; except it were *Fixt* to some other *Immovable Body*, and

Lastly, Because it must be supposed (tho' of that Vast Extent) to be a very *Light Body*: as being Composed of those most *Minute*, and *Subtle Particles*; and possibly *Thinner*, than a *Web* made of Single Threads of those *Spiders Spinning*, mentioned by Mr. *Leewenhoeck. Philos. Transact. Num. 271. Pag. 878.* 400000 of which being put together, would not make one so Thick as a *Hair* of a *Man's Head*: nay, possibly Thinner than the *Vessels* in the *Animalcula in Semine Masculino*, a *Thousand Millions* of which *Animals*, will lie in the Space of a large *Grain of Sand*; for even these, seem to be Composed of more *Crude Particles*, than that *Solid Orb*, and therefore if so, it may easily be Carried by these *Circulating Particles*.

C H A P. XIV.

THE *Sun*, and the rest of the *Planets*, being Placed; with their *Satellites*, upon their *Appropriate Orbs*, consisting of such *Elastic Springy*

gy *Particles*, as above mentioned ; put into *Circulation*, and consequently *Receding* from them before, as at *b, g, l* ; and strongly *Pressing* upon them behind, as at *a, e, i* ; they must carry these *Vast Bodies* in *Circulation* with them also : which *Motion* begun, the *Cause* continuing, it must continue also : the *Velocity* of which *Motion*, being upon a *Fluid Body*, must *Encrease*, for the same *Reasons*, that the *Motion of Bodies Descending Perpendicularly*, *Encrease* (as they proceed) in *Swiftness*. For as the *Planets*, upon their several *Orbs*, *Move* towards *p, f, w* ; the *Ethereal Particles* at *b, g, l*, besides their *Natural Tendency* that way, by their *Circulation* in the *Concave* of the *Firmament*, by the *Weight* of those *Bodies*, are *Darted*, or *Drove* *Furiously* before them, and consequently make a *Way*, in which they *Gradually* find less *Resistance* from them, whilst the *Particles* at *a, e, i*, by reason of their *Expansiveness*, rush *Gradually*, with more *Violence* upon them, and *Press* them more *Furiously* forwards, as they also *Move* *Quicker* before them. So that the *Causes* of their *Motions* *Encreasing*, and *Impediments* *Decreasing*, the *Motions* of the *Planets* themselves, must *Encrease*. And because there is nothing to hinder them, they being no nearer the *Centre* at *p, q, r, f, t, u*, &c. than at *a b, e g, i l*, &c. they must *Move* on, so long as the *Body*, and *Orb* endures. Because *Bodies* being put in *Motion*, if there be nothing to hinder them, will *Move* on for ever ; and *Encrease* their *Velocity*, till they *Arrive* to the utmost *Period*, that such *Movables*, with such *Causes*, are *Capable* of : which when they have done, that *Time* that is spent, whilst the *Sun* passes *Round* its *Orb*, is called a *Day* : Hence the *Diurnal Motion* from *East* to *West*.

From

From whence proceeds, First, That other *Supposed Motion*, from *West to East*; which is really no different *Motion*: but is occasioned by their slower *Motions*, about their own *Orbs* from *East to West*. For in that *Time*, that any *Fixed Star* in the *Firmament* runs Round the *Orb*, and comes to the same Place again, the *Planet Saturn*, will come so much short of it, in the same *Time* as to lose every *Day*, so much, that in *Seven Years and a half*, it will want *one Quarter* of its own *Orb*, of being at the same Place, or in *Conjunction* with the *Fixt Star* it set out with; in *Fifteen Years*, 'twill want one half; and in *Thirty Years*, will (by falling short) have gone Round his *Orb*, *Eastward*; and be in the same Place, or in *Conjunction* with that *Star* again. *Jupiter*, will want so much every *Day*, as in *Three Years*, to loose *one Quarter*; in *Six Half*; and in *Twelve*, performs its *Eastern Course*. *Mars* loses so much every *Day*, that in *Half a Years Time*, 'twill lose *one Quarter*, and performs its *Eastern Period* in *Two Years*. The *Sun*, in *one Year*, and the *Moon*, in *Twenty Eight Days*. For as the *Planets* are farther Distant from the *Earth*, so they run their *Course* from *East to West*, with more *Celerity*; but make their *Revolution*, from *West to East* slower.

First, Because the Higher they are, the Lighter they are in Proportion to their *Bulk*; and consequently, are easier *Moved*: for if the same Force of *Air*, or *Æther*, Presses upon a Lighter, that would *Move* a *Heavier*, it must *Move* the Lighter, with much more *Ease*; and consequently in a *Proportion*, swifter than the other, as 'tis Lighter than it.

2dly, Because they are *Nigher* to the Current of *Etherial Particles*, Circulating in the *Circumference*, with the *Fixt Stars* : which consequently, have a *Greater Power* to Affect them, than at a *Distance*, where their Force is *Weakened*.

And, *Lastly*, Because *Dense Body*, does more hinder a *Body* in *Motion*, than *Rare*, or *Subtle Matter* does ; and therefore the *Moon*, being *Lowest*, and consequently, Placed in the *Grosseft Medium*, is therefore *Slowest*, in Running Round her *Orb*, from *East* to *West* : so *Slow*, that She loses every *Twenty Four Hours*, the *Twenty Eighth Part* of her *Orb* ; and therefore *Quickest*, in making her *Revolution Eastward*, viz. in a *Month*. The *Sun* being in a much *Rarer Medium*, performs his *Diurnal Circuit*, with so much *Swiftness*, that it Runs near the *Twenty Eighth Part* of its own *Orb*, farther than the *Moon* does in its ; and comes, consequently, to the same *Point* again, in the same *Time*, viz. in *Twenty Four Hours*, tho' the *Diameter* of the *Sun's Orb*, is to the *Diameter* of the *Moon's Orb*, as 1150 is to 56½, according to *Tycho*, the most *Accurate Observer* ; and therefore the *Sun's Circuit*, is in the same *Proportion Bigger*, than that of the *Moon's*, and consequently, is so much *Swifter*. And because 'tis so *Beneficial*, and *Familiar* to us, we make its *Course*, the *Measure* of all the Rest.

2dly, As the Endeavour of the *Ætherial Particles* Upwards, accompanied with those other concurring *Causes*, puts the *Sun*, and other *Bodies* into *Circular Motion* ; so they *Floating* upon these very *Elastic Particles*, by the *Weight* of their own *Bodies*, Moved with incredible *Swiftness*, Dart them Downwards, not only to the *Centre*, but even to the *Opposite Part* of their own *Orbs* : (as

is evident by the *Angle of Reflection*, being *Equal* to the *Angle of Incidence*,) if not to the Opposite Part of the *Firmament* (or *Solid Orbs*.) Where by the way, they will *Rarify*, and *Dilate*, the *Central Atmosphere*, and Cause it to take up more Room : and consequently to make an *Impulse* upon the *Particles* that are contiguous to it, and to Push them from it. Which *Impulse*, by Reason of the Fulness of the *Ætherial Particles*, in the Cavity of the *Solid Orb*, will be Continued to the *Firmament* : where striking against that *Solid Orb*, they will be Beat down by the *Sides* of it, and by that means, continue Supplies to those *their Circulating Particles* ; which Cause the *Motion* of the *Fixed Stars* ; by which an *Universal*, and *Perpetual Circulation* is Continued.

3dly, The *Earth* being the *Centre*, and therefore Exactly Opposite to that Part of the *Sun*, viz. its *Centre*, that held the *Greatest Force* upon the *Ætherial Particles* ; the *Greatest Number* of those *Particles* will be Directed to it : and there being *Resisted*, and *Reflected* Back among themselves, by reason of their Great Numbers, and Activity ; they will particularly *Rarify*, *Dilate*, and *Distend* that part of the *Earth's Atmosphere*, that is *Opposite* to them, and contiguous to it, and consequently, make it take up more Room, and Press hard upon the *Earth*.

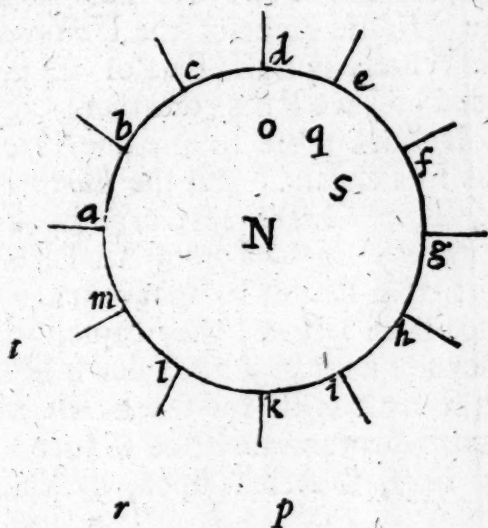
That this *Air*, or *Atmosphere*, is Capable of being *Dilated* by the *Rays of the Sun*, is evident from this *Experiment* : I took a Blown Bladder, and let out some of the *Air*, so that it became flaccid, and soft to the Touch ; and exposed it to the *Hot Rays* of the *Sun*, setting a Glass behind it to *Reflect* the *Rays* more Violently upon it : where after some Time, the *Air* in the Bladder was so *Rarified*, as to make the *Bladder* become

come hard, and tite to the Touch. And since it is certain, that the *Sun* has *Power* to *Rarify*, and *Dilate* this *Air* thus Bent; we may conclude, it has the same *Power*, to *Rarify* and *Dilate*, that which is Free. This consisting of the like *Springy Particles*, with the other; and consequently make it take up more Room, and *Press* hard upon the *Earth*; which *Pressure*, will likewise give a *Circular Motion* to the *Earth*. For suppose it to be supported (as it is) by *Aerial Particles*, and those *Particles*, or its *Atmosphere*, to be so *Dilated* on this side, by the Presence of the *Solar Particles*, as to *Press* strongly upon the *Earth*, and to *Drive* it fromwards 'em: and the *Air*, or *Atmosphere*, on the Opposite Side of the *Earth*, to be so *Condensed*, in the Absence of the *Solar Particles*, as to take up Less Room, and consequently to give Way to it; by its *Atmosphere's* bearing strongly upon it, upon this side, and receding on the other, the *Earth* will be Moved from its *True Centre*, or *Exact Middle of the Universe*, to a Place Distant from it; but still Opposite to the *Sun*. And as the *Sun* in its *Circle* Round the *Earth*, Moves to another Part of it, so the *Pressure* of the *Solar Particles* upon that Part of it, where 'tis Present, will thrust it as before to the Opposite Part of it; and so successively, in a *Circle*, as it Moves about it: for *Example*,

Suppose *n*, a *Body*, equally supported on all sides by the *Props* *a, b, c, d, e, f, g, h, i, k, l, m*; if the *Props* *b, c, d, e, f*, be so Lengthned, or Thrust Forwards, as to *Drive* it before them to *o*; and the *Props* *h, i, k, l, m*, be Shortned, or Recede, and admit it to *p*: it is manifest that this *Body*, will be Moved by the *Pressure* of the *Props*, *b, c, d, e, f*, so far out of its Place, as there is Distance betwixt *d*, and *o*, or *k*, and *p*.

But

But now if these Props *c, d, e, f, g,* should be Thrust Forwardst o *q,* the and Props *i, k, l, m, a,*



should Recede to r , the Body n , would be Carried to q , and r , and then if the Props d, e, f, g , should be Moved forwards to f , and the Props k, l, m, a, b , should Recede to r , the Body n , would be carried thither also : and so Successively Round about.

In like manner, suppose n , the *Earth*, supported on all Sides by *Aerial Particles*, and the *Sun* to be *Perpendicular* to d , and to Dart the *Particles* on that *Hemisphere* betwixt a , and g , and to *Distend*, and *Dilate* that Part of the *Atmosphere*, so as to make it *Press* the *Earth* strongly towards p : and at the same time the *Particles* betwixt g , and a , on the other side; by reason of the Absence of the *Sun*, to be *Condensed* at k , chiefly, and consequently giving way to the *Power* of the abovementioned *Solar Particles* at d ; the *Earth* must proceed to p . And when the *Sun* comes to be *Perpendicular* to e , by the same Rule 'twill be Directed to r , when to f , to

f, to *t* ; and so on successively, in a Circle opposite to the *Sun*, as it Moves about the *Earth*.

But, tho' the *Earth* Moves thus in a Circle Round the Middle Point of the *Universe* ; yet neither the Whole, nor any Part of it, tho' it be Compounded of Two Parts, one more Light than the other, inclines more to any one Place, than another, as to a *Centre*. But the *Earth* still Remains the True *Centre of Gravity* ; and All Things Naturally Descend from All Parts of the *Universe*, to that Part of it, that is next to them ; as to a Place from whence they came, and from whence they are kept by Force ; let it be in what Part of its *Orbit* it will, for the *Earth* will then be in the most Appropriate Place to such a *Grave*, and *Dens Body*, so Acted upon, by such *Solar Particles*.

And as the *Earth*, is by all, allowed to be a *Point*, when compared to the *Firmament* ; because on what Part soever of the *Earth* the *Eye* is Placed, it always beholds one Half of the *Firmament* ; and the *Stars* therein appear to him, to be always the same ; neither Bigger, nor Less. 'Tis likewise allowed to be a *Point*, in Respect of the *Sun* : because the *Shadow Moves*, as Regularly about the *Centre* of the *Dials*, placed upon the *Superficies* of the *Earth* ; as if they were in the *Centre*. So that in Respect of the *Sun*, there seems to be no Difference between the *Centre*, and the *Superficies*. And as the *Earth* in Respect of their *Bigness*, is said to be a *Point* ; so in Respect of the *Celerity* of their *Motions*, it may be said to stand still : for this in all likelihood, is Spoken Respectively. For 'tis not probable, that a *Body*, supported by so variable an *Atmosphere* should at any Time be Absolutely Quiet, if there

be any Thing in *Nature* that ever is; which may be *Questioned*.

And as there is no Part of the *Earth*, that Inclines more to one Part, or *Place* than another; as to a *Centre* (as all other *Bodies* do:) So all its *Parts*, do always, for that Reason, keep the same *Situation*. As that Part which looks towards *b*, always looks towards *b*; and that Part that looks towards *c*, always looks towards *c*; let the *Earth* be in what Part of its *Orbit* it will.

4thly, There will proceed a *Motion* of the *Planets* about their own *Axis*, Common to all, but the *Moon*: for supposing them to be *Spherical Bodies* (nearly in all Parts of the same *Weight*) not *Mathematically*, but *Physically* speaking, that is, admitting of Great *Irregularities* on their Surface, as the *Earth* does, of *Hills*, and *Mountains*, which by the *Telescope*, they Really appear to do, and Rapidly Floating upon a very *Fluid Medium*; by Reason of the *Inequalities* of their Surface, the *Medium* will find a Greater *Resistance* in one Part, than another: and when a *Body* put in Violent *Motion*, is hindered more in one Part than another, that Part so hindered, will put the whole into a *Rotation*, about its own *Axis*: as hath been proved before. And as it Causes a *Rotation* about its own *Axis* so,

5thly, Being upon a very *Fluid Medium*, 'twill Cause the *Planet* to Decline a little from the *Equator*; because the *Current* of *Ætherial Particles*, will not fall with Equal Force on each side the middle Point of it; but more Forcibly, on that where it finds *Greatest Resistance*: which will Cause it to decline towards the *Tropic*: and because the same *Power*, has still the same *Force*, upon the same *Body*, 'twill continue so to do; out every Day less than other. The *Air*, or *Æ-*

therial Particles, as it Approaches farther that Way, being more Impregnated with *Nitrous Particles*, (as I shall shew here-
 * *Vid. Chap. 27.* after *) which will, therefore, more Forcibly Resist the *Sun's Motion* that Way: it being highly Impregnated (as we must suppose) with *Ætherial Particles*; to which they make a Constant *Reluctancy*. So that when it comes to the *Tropic*, 'twill there find so Great *Resistance* from them, as will put a stop to its *Progress* that way: and after some Days, Force it Back again Gradually, as it came: and because there is nothing in so *Rare* a *Medium*, that can stop the Tendency, of so Great a *Body* that way, 'twill move Forwards, till it come to the Opposite *Tropic*. Where for the same Reason, 'twill be turned Back again, and so Backward, and Forward, from *Tropic* to *Tropic*, (as a Piece of Wood upon Water, from Bank to Bank,) for Ever: the *same Causes*, having the *same Effect*, upon the *same Body*: And that Time, that the *Sun* takes up, in Moving from one *Tropic* to another, and thence Back again, is called a *Year*. Whence the *Annual Motion*.

And because from the *Equator*, it Moves every Day Gradually slower, as it approaches the *Tropic*; therefore the Encrease, or Decrease, of the *Length of the Day*, is every Day Greater or Lesser, as it approaches nearer to, or farther from, the *Equator*.

The *Circumgyration* of the *Sun* about its own *Axis*, is such, that its *Axis* does not always keep the same *Inclination*, to the *Plane of the Ecliptic*; but Moves sometimes more Obliquely, sometimes less Irregularly: Which possibly may proceed, from those vast Polished Mountains, which are observed sometimes to Glide, sometimes to

stick strong

stick upon its Surface. For as they Move their Situation, so they may Alter the Centre of the Sun's Gravity; by making that Part they move into, more Ponderous, than that they Moved from, and so make the Greatest Resistance, to the Fluid Medium it Floats upon, in a Part different from what it was before. And, consequently, Cause a Different Motion about its own Axis, as either More, or Less Oblique, than it was before: and possibly they may damage the Place they stick upon, and leave it less Polished, than the rest; which may Cause that Black Spot behind them; if it be not the Shadow of them.

CH A P. XV.

THE Three Superior Planets, have the same Motion about their own Axis, and Declination North, and South, as the Sun: but differ from it, as the latter in them is Greater, and the first Swifter. Which may come to pass; First, Because those Irregularities in their Surface, may be Greater, and so the Motion about their own Axis Swifter. 2dly, Those Irregularities may be differently Posited, and so their Motions may be in a Different Manner: as with their Poles, more or less Parallel to the Equator. And, Lastly, their Declination North, and South, may be Greater; First, Because their Irregularities are Greater on their Superficies, and their Motion about their own Axis is Swifter: which will Cause their Declinations from the Equator, to be stronger; and consequently farther. 2dly, Be-

a use, as the *Sun*, Moves the *Earth* in a Circle from *East* to *West*; so when it is in its utmost *Declination*, either *North*, or *South*, it will Move the *Earth*, (it being always in Opposition to it,) something more *North*, or *South*, (tho' its *Poles*, and *Equinoctial Points*, keep the same *Situation*:) which will Cause the *Planets* at those Times, that are in their Greatest *Declination*, to seem farther off, or in *Greater Latitude*, either *North*, or *South*, than the *Sun*.

From these *Motions* of the *Planets* already accounted for; which may be called *Primary*: because from these, Result many *Secondary Motions*, and Different *Phænomena*, observed amongst them, some Common to all, some Particular to each of them. And, First, 'tis observed in all the *Planets*, that they do not always *Rise*, or *Set* in the same *Place* of the *Horizon*: but that they *Rise* sometimes from that *Place*, where the *Sun* Rises in *Summer*; and sometimes from the *Place*, where it *Rises* in *Winter*. In like manner, that they sometimes go down, in the *Place* of the *Winter Sun-setting*; sometimes in the *Place* of the *Summer Sun-setting*. Again, that under the *Meridian*, they go sometimes Higher towards the *North*; sometimes Lower towards the *South*. Besides, That there are Certain Bounds, or Limits, that they neither pass towards the *North*, or *South*, in their *Rising*, or *Setting*; nor are they *Elevated*, or *Deprest*, beyond them, when they are *Culminate*. All which comes to pass, because the *Planets* have the same, but a farther *Declination* towards the *North*, and *South*, than the *Sun*: Wherefore, they must have the same, or a *Greater Variation*, as to their *Rising*, and *Setting*.

2dly, That they have divers *Situations*, both in Relation to one another, and also to the

Fixt

Fixt Stars : and that sometimes in their *Conjunction*, or Approaches to One another, the *Fixed Stars* are covered by the *Planets* ; and sometimes the *Planets* by one another : And yet not all alike, with Respect to all the Inhabitants of the *Earth*.

This comes to pass, because they are all *Gradually* One Slower than the other, in their *Course* about their *Orbs*. So that in the Time, that that *Fixed Star*, that *Saturn* is in *Conjunction* with, Runs about its *Orb*, and comes to its Place again, the rest will Gradually want, One more than the other, of coming to the same *Point* ; as they are One Slower than the other, in their *Course* from *East* to *West*. As in the *Figure* above, *Saturn* will be but at *a*, *Jupiter* at *e*, *Mars* at *m*, *Sun* at *i*, *Moon* at *n*, and tho' *a, e, m, i, n*, seem to be Directly under One another ; yet in Proportion to their *Orbs*, One losses much more than the other : Which must necessarily Cause a *Different Situation* from what they were in before, both in Relation to themselves, and *Fixt Stars*, being then Distant from each other several *Degrees*. But when they Approach so near one another, as to be in, or near the same *Degree* and *Minute*, both as to *Longitude*, and *Latitude*, (as they must sometimes do :) Because they are so Posited upon their *Orbs*, as to be One Lower, or Under the other ; the Lower will Intercept the Light of the Superior, and hinder it from Illuminating that Part of the *Earth*, that is Perpendicular to it ; but not from Illuminating all other, that are in a different *Latitude*.

3dly, The same *Planets* seem to Move, at sometimes Faster, at sometimes Slower, than they do at others : because when they are in *Perigee*, or *Opposition* to the *Sun*, the *Arc* of their

Circle, which is above our *Horizon*, tho' it seems to us, to be the whole *Hemisphere*; yet is much Less than the Opposite Part, or that below our *Horizon*; as may be seen in the abovementioned *Figure*, where the Line x, y , divides them. But because this *Arc*, is less than a *Semicircle*, and the *Planets* always keep the same Pace in their *Course*; they must Run thro' this seeming *Semicircle*, as much Sooner, as 'tis Shorter; and therefore will be thought to do it Faster: On the the contrary, in the Opposite Part, its *Arc* will be as much Longer, than the *Semicircle*, as this is Shorter; or as the *Arc* $x a y$, is Longer than $x q y$; wherefore they will be Double as much Longer in Running thro' This, as they were Sooner in the Other, then they would have bin in a *Semicircle*: and consequently, will seem now to be as much Slower, as before they were Faster.

4^{thly}, They seem to be sometimes *Bigger*, sometimes Less. From whence the Ancients did always conclude, that they were sometimes Nearer, sometimes Farther off: For say they, if a *Planet* appears sometimes *Bigger*, sometimes Less; 'tis a plain Argument, that they are sometimes Nearer, sometimes Farther off. Because the *Apparent Diameter* of a *Planet*, is lessened, in Proportion to the Increase of its Distance from the Earth; and this will hold true in those that have always the same Height, which is only the *Sun*, if any. For possibly, It may as well receive Luminous Ray's from them, as they from It: When they are in *Opposition*; tho' not in such Proportion (by Reason of its already too great Lustre) to be discernible by us. For those that have a borrowed Light, appear *Bigger*, or Less, as that Part towards us, is More

or Less Illuminated ; as is apparent by the *Moon*, whose Luminous Part, when but Three Days removed from *Conjunction* with the *Sun*, to us seems not, the Tenth Part so Big, as when 'tis in the *Full*, or *Opposition*. Whence 'twill follow, that the *Planets*, when they are in *Opposition*, to the *Sun*, must seem to us to be abundantly Bigger, than at other Times.

First, Because they are really Nearer, by the Length of the Diameter of the *Earth's Orbit*, (and therefore may be found to be so by the *Parallaxes* ;) which *Orbit*, because the *Air*, or *Atmosphere*, is capable of being *Rarified*, and *Condensed* to such a Degree, as to take up 520000 Times more space at One Time, than another ; possibly may be Greater than some will suppose.

2dly, Because their whole *Hemisphere*, when they are in *Opposition* to the *Sun*, appears *Illuminated* ; which at other Times, only appears but in Part.

But it may be Objected, that the Three *Superiour Planets Moving in Orbs* above the *Sun*, are also at *Full* when in *Conjunction* ; that Part, that is then Exposed to us, being Next, or Opposite to the *Sun*, and consequently, should appear as Big to us, as when they are in *Opposition* to the *Sun*.

To which I Answer, that the *Sun* is supposed to cast its Rays upon that Half, that is Exposed to Us, when they are in *Conjunction* ; yet it will not appear so to Us.

First, Because, till they are separate at some Distance from the *Body* of the *Sun*, and are likewise above our *Horizon*, when the *Sun* is Below ; by Reason of its much Greater Lustre, they are Totally Invisible.

2dly.

2^{dy}, Because they Receive none, or very little *Light* from the *Sun*, till they are so far separated from it, as to be Exposed to some of those *Rays*, that are Darded from the *Suns* Lower Hemisphere, that floats upon, and is supported by, those *Ætherial Particles* that are next to us: And then by Reason of its Great Distance, it will but little Affect any of those *Superiour Planets*, except the Lowest, viz. *Mars*. For when it comes in *Square* to him; 'twill so Illuminate that Part it shines upon, as to Distinguish it from the other, and make it appear almost Bisected. But as to *Jupiter* and *Saturn*, it little Affects them, till they come into *Opposition* with it; where the *Sun* from its Centre, Darts the *Ætherial Particles* with so much Force, as to give an Additional Lustre, even to the Face of *Jupiter*, and consequently make it appear Brighter, and Bigger.

C H A P. XVI.

THAT the *Sun* does not give any discernible Light, to the Two *Superiour Planets*, at any other Time than when they are in *Opposition* to it; seems reasonable to be supposed. First, Because the *Sun*, and *Moon* are said, Genesis 1st. to be Two Great Lights, or Distinction from the other Lights; which must be in respect of Us: Otherwise 'tis Demonstrable that the *Moon*, is the Least of all the Lights (except perhaps some of the *Satellites*.) And the Greater Light was made to Rule the Day, and the Lesser

ser to Rule the Night ; which seems to intimate, that they were made, Chiefly for our Use ; and therefore as they are placed Nighest, so they should chiefly Dart their *Light* to Us : And indeed it cannot be supposed that the *Sun* should strike those *Particles*, that fall upon the Upper Part of it, and which by their *Natural Circulation* Move before it ; and on the Back Part, have no Greater Tendency towards it, than what proceeds from their *Expansive Pressure*, upon a Body that recedes from them, up to those *Planets* that are above it : When in or near *Conjunction* with it, with a Quarter of that Force, as it will those downwards upon which it Floates, the Gravity of the *Body* being here Added to its Celerity. Moreover the *Elastic Springy Particles* do here, besides their *Expansive Pressure*, make a greater Resistance, as they are Forced to support its *Body* ; which must needs add, incomparably to its Power to Reflect them.

3dly, That *Saturn* and *Jupiter* receive not their *Light* from our *Sun*, may be argued ; First, Because their Whole *Bodies* always appear Illuminated, even thro' the *Telescope*.

2dly, Because they give *Light* to their own *Satellites* : As is evident, First, because the *Satellites* are Totally Obscured to us, when that Part that is turned towards their *Sun*, or *Saturn* is turned from Us ; tho' that Part that is next to Us, is turned towards our *Sun* : Which if it had Power to give *Light* to *Saturn*, would likewise illuminate them ; but this it does not do, is evident. Because the same *Satellites* are seen to Us, sometimes *Bigger*, sometimes *Less* ; because they receiving their *Light* from that *Planet*, have the same *Phases*, as the *Moon*, *Venus*, and *Mercury* have, that borrow their *Light* from the *Sun* :
And

And appears *Bigger*, or *Less*, as that Part that is Illuminated is turned to, or from Us. So that when, but half that Part of the *Satellites* that is Illuminated, is turned to Us, they will seem but $\frac{1}{2}$ Part as Big, as when the Whole is Illuminated. For the *Angles* of the *Luminous* Part, being too Small to affect the *Eye*, at that Vast Distance; are cut off, and only the Middle of the Enlightned Part appears to Us like a Round, and Full Body, as is evident in *Venus* and *Mercury*.

But they would be always of the same Bigness, if they received their Light from our Sun, as *Saturn* and *Jupiter* are: Because always their Illuminated Part, would be as much Exposed to Us, or that of these *Planets*; which they say always appear Full, by Reason of their great Distance.

Neither can their *Bigness*, or *Smallness*, be ascribed to their Nearer or Farther Distance from Us; for that is inconsistent with that Observation of *Galileus*, in His *Nuncius Siderius*. Where he say, Die 19. '*Hora Noctis Secunda talis fuit Stellarum coordinatio erant nempe Secundum rectam lineam ad unguem, Tres Ori-*



'occ. Cum Fove Stelle: Orientalis una distans
'a Fove min. pr. 6. inter Fovem & primam sequentem occidentalem, mediabat min. 5. interstitium; hæc autem ab occident aliori aberat min. 4. anceps eram tunc numquid inter Orientalem stellam & Fovem stellula medicaret, verum Fovi quam proxima

proxima, adeo ut illum fere tangeret at hora: quinta hanc manifeste vidi medium jam inter Jovem, & orientatem stellam locum exquisitè occupantem adeo ut talis fuerit, Ori.



Configuratio stella in super novissime conspecta admodum exigua fuit, veruntamen Hora Sexta reliquis magnitudine fere fuit aqualis.

Now supposing *Jupiter* according to *Copernicus*, who is a Mean betwixt *Tycho* and the Ancients, to be 809 of the *Earth Semidiameters* distant from Us: 'tis impossible that a *Star* that never Moves above a few *Minutes* distant from *Sun*, or *Jupiter*, should become so far near Us, as to appear near as Big again, in an *Hours* Space. But supposing the *Satellites* to have their Light from their own *Planets*; it may easily be conceived, that one that moves in a *Circle* about it, and very near to it, may be so placed, as to seem to us almost *Twice* as much illuminated in an *Hours* Space, as it did before. Considering how swiftly that *Planet* Moves about its own *Centre*, viz. in Ten Hours; and its *Satellites* with Proportionable *Celerity*. Nor can it be supposed that the Bigness of this *Satellite*, should be diminished, by being so near the Rays of this *Planet*: For this was separate Three *Minutes* from the Body of *Jupiter*. When in Page 36 in His Observation on the 16. Day, and 21. Day, and in several other Places, He observes *Satellites* as big as this was, when at the Biggest

Biggest, that were not a *Minutes* Distance from their *Planets*. From these *Observations*, and from many others there made; 'tis Apparent, that they receive their Light from that *Planet*, and not from the *Sun*; and consequently not the Two *Superior Planets* neither.

3dly. This seems to be confirmed; because the Inside of *Saturn's Zone*, upon which the *Planet* casts its *Rays*, is always Illuminated, when the out side, that is exposed to our *Sun*, is Dark except some little Streaks, that seem to have Passage from the *Nipes*, or Inequalities of the Edges.

4thly. We could not Participate of the *Ætherial Particles*, of those *Upper Regions*, were it not thus. For if they had only their Light from the *Rays* of the *Sun*; it would only be those *Rays*, that are Reflected from them to Us: Which being at so Great a Distance, and so Faint, cannot be conceived to have any Great Effect upon Us. Since we are Daily conversant with the same, in their Greater Force. The *Astrologers* tell us, of stupendious Effects, especially from the *Conjunction* of those Two Great *Luminaries Saturn* and *Jupiter*. Which may be a *Consequence*, easily Accounted for, from the Effects of those Purer *Ætherial Particles*, darted by those *Bodies*, from those *Upper Regions* upon us, and more furiously Agitating the several *Juices* contained in our *Bodies*.

5thly, *Desimilibus similis est Ratio*; Therefore since these Run the same Course between the *Poles*, Dividing the *Globe* into Two Equal Parts, as our *Sun* does, are attended with like *Satellites*, that constantly Move Round them, and borrow their Light from them: As *Mercury* and *Venus* do, which I take to be Our *Suns* *Satellites*.

First

First, Because they move about Our *Sun*, as they do about theirs. *2dly*. Because they are Exactly of the same *Height*, or *Distance* from the *Earth*, (according to the Most Accurate *Tycho Brahe*,) as the *Sun* is. And *Lastly*, Because they have Exactly the same *Annual Revolution* about the *Earth*, as the *Sun* has. I say, since there is so great a similitude betwixt those Two *Superiour Planets*, viz. *Saturn* and *Jupiter*, and the *Sun*, that these *Planets* are *Suns*, or *Bodies* in all Respects the same to their *Satellites*; and the *Bodies* adjacent (if any such there are,) as the *Sun* is to its *Satellites*, and these *Inferiour Regions*.

5thly, 'Tis observed, that the Three *Superiour Planets*, approach more and more every Day towards the *Eastern Stars*: But yet that they are Sometimes *Direct*, i. e. Move into the Signs following, or according to the *Order*, or *Succeſſion* of the *Houses*, as from *Aries* into *Taurus*; from thence into *Gemini*, &c. Sometimes to be *Retrograde*, or Contrary to the *Order* of the *Signs*, as from *Aries* into *Pisces*; thence into *Aquarius*, &c. And sometimes they seem to be *Stationary*, or not to Move into the One or the other; neither into the *Antecedent*, nor *Consequent Signs*.

2dly, That they are always *Retrograde*, and are both *Swiftest* in their *Retrocession*, and greatest in *Aspect* or *Appearance*, when they are in *Opposition* to the *Sun*, and Shine all Night above the *Horizon*.

3dly, That *Saturn* is oftner *Retrograde*, than *Jupiter*, and *Jupiter* than *Mars*. Again *Saturn* has a longer *Space* of *Retrogration* than *Jupiter*, and *Jupiter* than *Mars*. *Lastly*, that the *Arc* of *Retrogration*, is always Less than the *Arc* of *Directiō*.

This

This comes to pass ; *First*, because the *Earth* or the *Sun* (for 'tis the same Thing) Moves *Slower* in its Course from *East* to *West* : And consequently Approaches toward the *East*, faster than the Three *Superiour Planets* ; so that, whilst *Mars* that Moves *fastest Eastward* of the Three, gets One Degree towards the *East*, the *Earth* gets Two. And therefore, when *Mars* is in *Opposition* to the *Sun*, as in the Figure Page 89 at *z*. as *Mars* Moves One Step towards the *East*, the *Earth* Moves Two. Because We that are the *Inhabitants* of the *Earth*, do suppose Our selves and the *Earth*, to stand still ; *Mars* will seem to Us, to Move every Day One Degree from us, towards the *West*, and so will continue to do till it comes to 6 or 7, on the *Right Hand* of *z* ; for supposing *Mars* to be in *Opposition* to the *Sun* at *z* ; in the Time that *Mars* gets *Eastwards* to 2, the *Earth* will be at 3 ; by that Time it gets to 3, the *Earth* will be at 5 ; and so on till it comes to 6, or 7. at which time the *Earth* will be at 11, or 12 ; because we then see it 5, or 6 Degrees *Westward* from Us, we conclude it has Run far Back, since we were together at *z*. But then, because betwixt 13, and 6, or 7, we Move in a *Straight Line* from it, it will appear to Us to Move neither *East*, nor *West* ; but to be *Stationary*, till it comes to 13, at which Time, we shall be at 14, on the *Left Hand* of *z* : and then 'twill again, for the same Reason as before, seem to be farther from us every Day towards the *West*, and continue so to do, till *Mars* comes at *Sun Rising*, to be in *Conjunction* with the *Sun*, and in *Opposition* to the *Earth*. But then, because the *Earth* goes Two Steps towards the *Eastern Signs*, as *Mars* goes One, *i. e.* in the Time that *Mars* gets from *Conjunction* with the

Sun

Sun, to 19 on the Left Side, the *Earth* will be got to 3, from 2, on the Right. When *Mars* comes to 18, the *Earth* will be at 5, when at 17 at 7; so that *Mars* will be every Day nearer the *Earth*, Eastward One Degree: or seem to Us, to come Back again, and to be every Day farther from the *Sun*, as We get nearer to *Mars*. And because we see *Mars* several Degrees nearer to us Eastward, since it was in *Conjunction* with the *Sun*, and in *Opposition* to the *Earth* at 2; we suppose it has got so many Degrees nearer us Eastward, Direct, or according to the Due Succession of the Houses, or Order of the Signs. And it will continue so to do, (as in the Time of its Retrocession, till the Next Years End) when it comes again to be in *Opposition* to the *Sun*.

2dly, The Superior Planets are always Swiftest in their Retrogradation, when in *Opposition* to the *Sun*. Because then they Move not at all in a Right Line towards us, but in a Line Directly Transverse to us: They are then always bigger in Aspect, or Appearance, because they are then always Nearest to Us; and (in respect of us) most Illuminated by the *Sun*, as has bin proved above.

3dly, *Saturn* is oftner Retrograde than *Jupiter*; and *Jupiter* than *Mars*: because *Saturn* moves slower into the consequent Signs than *Jupiter*; and *Jupiter* than *Mars*. And therefore, the *Sun* getting more Ground of *Saturn* than of either of the other, overtakes it sooner, and therefore oftner, & sic de ceteris.

Again, that Planet the Semidiameter of whose Orb, bears the Greatest Proportion to the Orbit of the *Earth*, has the Least Space of Retrogradation. As is visible in the Figure, and may be observed in this Present Year 1702, where *Mars* falls

Falls *Retrograde*, on the 28th of *May*, and continues so till the 2d of *August*; which is little more than two *Months*. *Jupiter* falls *Retrograde* the 21st of *July*, and continues till the 22d of *November*, which is near as long again. And *Saturn* beginning to be *Retrograde* the 13 of *July*, and continuing till the 27th of *November*, is *Retrograde* 13 Days longer than either of them.

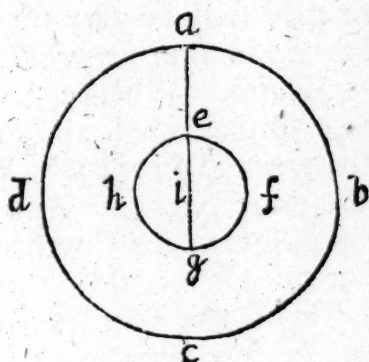
Lastly, Because the *Arc* of the Superior *Planets*, when they are in *Opposition* to the *Sun*, is Less above our *Horizon* than in the Contrary Part; (as has bin shewed before,) therefore the *Arc* of *Retrogradation*, is always Less than the *Arc* of *Direction*.

C H A P. XVII.

THE Two Greater *Lights* have not the same *Phenomena*. For, First, The *Sun*, because we are always in *Opposition* to it, can neither seem to *Move Faster*, or *Slower* (as the Superior *Planets* do; tho' they always in Reality keep their constant Rates:) to be *Stationary*, or *Retrograde*. But because we suppose Our selves to stand still; and are always in the same *Position* in respect to the *Sun*, and supposing it to drop short of the *Fixed Stars*, every Day in its Circuit from *East* to *West*: it must to us seem always to *Move* in *Consequentia*, or into the *Eastward Signs*. As suppose *i g*, *i a* were *Radii* from at *i*; its plain that the two Ends would describe the *Circles*, *a, b, c, d*, and *e, f, g, h*. But suppose *a*, the *Sun*, and *g*, the *Earth*; *a*, could

never

never seem to the Inhabitants at *g*, to *Move Faster*, or *Slower*, to be *Stationary* or *Retrograde*.



Because *g*, does by the same *Motion* describe as many *Degrees* of the *Circle*, *e, f, g, h*, as *a*, does of the *Circle*, *a, b, c, d*, (as *p. Cor. of Prop. 33d* of *Euclids 6th Book* may be *Demonstrated*.) Therefore *g*, will *Move*, tho' in a *Less Circle*, as *a*, does, from *East to West*, and from *West to East*, or from *North to South*, and at no time either More or Less, wherefore *a*, must seem to the Inhabitants at *g*, to keep on *Constant Motion*.

The Reason why the *Diameter* of the *Sun*, is said to be almost a *Minute Bigger*, and consequently *Nearer*, when in the *Tropic of Capricorn*, than in the *Tropic of Cancer*, is by reason of the *Greater Refraction*. For if we conceive the *Atmosphere* of the *Earth*, or the *Vapours* that surround it, to be as they really are, a *Body of a Globular Figure*, whose *Centre* is the same with the *Centre of the Earth*, and suppose the *Sun* to be in the *Horizon*, 'tis clear the *Rays* will fall very *Obliquely* on that Part of the *Atmosphere*, that hangs over our Heads: for they will fall upon it in the same manner, that they Fall upon the *Surface* of the *Earth* that is under our Feet: and

then when the *Rays* of the *Sun*, out of the more *Pure* and *Thin Æther*, do enter into the *Vaporous Air*, that *Inclines* something to the *Nature* of *Water*; then they will be very much *Collected* and *Refracted* towards the *Perpendicular*, that *Falls* from Our *Zenith*. Whence it must needs be, that the *Rays* so *Collected* and *Refracted* to our *Eyes*, must shew the *Sun* to be *Bigger*, and *Higher*; and therefore *Nearer*. And *Experience* shews, that *Refractions*, even in the same *Horizon*, are *Greater* or *Less*, according to the *Thick-ness* or *Thinness* of the *Vapours* in the *Air*: which towards the *Northern* side of the *World*, do generally *Encrease*; because the *Air* is *Thicker* there, being *Condensed* in the *Absence* of the *Sun*. Whence it came to pass, that the *Hollanders*, *Wintering* in *Nova Zembla*, after a *Continual Night* of some *Weeks*, the *Sun* appeared to them above the *Horizon*, sooner than they *Expected*, according to the *Elevation* of the *Pole*, which they had taken.

And it cannot be supposed, but the *Gross Vapours*, *Condensed* by the *Frigorific Particles* in the *Absence* of the *Sun*, in the *Winter Time*, must *Compose* an *Atmosphere*, so different from the *Summers*, where the *Sun* by its *Presence* has *Subtilized*, and *Dissipated* these *Vapours*, as to make the *Diameter* of the *Sun* *Appear* by a *Minute* *Bigger*, and *Nearer* under the *Tropic* of *Capricorn*, than under the *Tropic* of *Cancer*. This likewise seems to be the *Reason*, why those *Fixed Stars*, that are *Near* the *North Pole*, seem *Nigh-er*, than those under the *Ecliptic*; the *Pole Star* than *Sirius*.

And moreover, because of the *Continual Dimi-nution*, or difference of *Refraction*, as the *Sun As-cends*, or *Descends*, 'tis as the *Lower Edge* of the *Sun*,

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Sun, being a little more *Refracted*, than the *Upper*, it seems to be drawn Nearer together towards it. Whence it comes that the *Sun*, at his *Rising*, or *Setting* does not Appear exactly Round, but *Elliptical*, or *Oval* ; having its *Perpendicular Diameter* more Contracted, than the *Cross Diameter*. And the *French* have observed, that there are different *Refractions*, even in the Midst of *Summer*, when the *Sun* is in the same Part of the *Horizon*, and on a Day as free from *Clouds*, and for any thing they could perceive, in all respects, as clear as the other. *In the Measure of the Earth, Made by diverse Members of the Royal Academy of Sciences at Paris.* Translated by *Waller*.

C H A P. XVIII.

THE *Moon*, because it *Moves* Slower than any other *Planet*, will always be *Direct*, like the *Sun* ; and can never seem to us to be *Stationary*, or *Retrograde*. By reason, that it *Moves* so *Slow* about its own *Orb Westward* ; and consequently so *Swift East-ward*, finishing its *Period* in a *Month*, as the *Sun* does his in a *Year* : getting near Twelve Times as Fast into the consequent *Signs*, as the *Sun* does. By which 'twill seem to us, every Day to drop short a considerable Distance, *viz.* a 28th Part of its *Orb* : as it really does, and will always in all Parts of its *Circuit* do the same.

First, Because it Loses so much, that 'tis so visible that it can seem no otherwise.

2dly, Because there is no other *Planet* betwixt us and it, that *Moves* faster into the *Eastern Signs*, to make it seem (like the *Superior Planets*) to *Move* otherwise than it does.

Besides this, it has many other *Phænomena* differing from the *Superior Planets*.

First, That it *Moves* not about its own *Axis*, but keeps always the same Part towards the *Earth*.

2dly, The *Moon* is not always (like the *Superior Planets*) in *Apogee* in *Conjunction*, and *Perigee* in *Opposition* ; but is sometimes the one, and sometimes the other in all Parts of its *Orb*.

3dly, That it has a *Libratory Motion* from *East* to *West*, and from *North* to *South*.

4thly, That it has Five or Six Degrees more *North Latitude*, than the *Sun* has.

5thly, It has various *Phases*. And,

6thly, Very observable *Eclipses*.

First, I conceive the *Moon* may always Appear to us with the same *Face* ; for Two Reasons. *First*, Because it may be much more *Ponderous* in one Part than another : and then the most *Ponderous* will always look towards the *Centre*. 2dly, Because its *Northern*, and *Southern Poles*, like the *Earth*, are much Impregnated with *Nitrous Particles*, that Flow from the *Northern*, and *Southern Poles of the World* ; and beat upon, and highly impregnate them. In which Case, if they should turn towards the *Ecliptic*, or *Way of the Sun*, by the Luctation of the contrary *Solar Particles*, they would there meet with, they would be Forced back again ; and to keep their own *Stations*, as the Ends of the *Mariners Needle*, are towards the *North*, and *South* : for the same reason.

2dly, The Moon, is not like the Superior Planets, always in Apogee, when in Conjunction, nor in Perigee, when in Opposition to the Sun, (as by this Hypothesis it may seem to be.) For as the Earth is drove from the Moon, in the Time of its Conjunction, by the Pressure of the Sun, or its Rays Dilating the Atmosphere : So the Moon, for the same reason, viz. the Pressure of the Sun, or its Rays Dilating its Atmosphere, and Acting upon it as it does upon the Earth, is Forced to follow the Earth : and when in Opposition, to fly before it. And so to keep constantly pretty near the same Distance from it; by getting ground one way, as it loses it another : So that when the Moon is in Conjunction with the Sun, the Pressure or Force of the Sun's Rays, and the Gravity of its own Body, in a Rarified Atmosphere, or Air, will sink it down to *A*, in the Figure, p. 89. When in Opposition, the Air on which it Floats, by reason of the Distance of the Sun, and Interposition of the Earth, will be so Condensed, as to Raise it up to *b*.

But then, 2dly, The Moon is sometimes in Apogee, sometimes in Perigee, when 'tis in Opposition to the Sun; and the same, when in Conjunction, and in all other Parts of its Orb.

And this proceeds from its Northern, or Southern Latitude : for when it is in its Northern Latitude, it seems nearer to us, who are Inhabitants of the Northern Part of the Earth; and when in its Southern Declination, farther off.

Coley's Almanack, for this Year 1702, in which there is an Account of the Moons Apogee, and Perigee; and likewise of its Northern, and Southern Latitude, will make this plain.

For here in the Month of April, you will find the Moon is at the Full, or in Opposition to the

Sun, the First Day; and in its *Perigee*, at the same Time: and in *Apogee* the 15th, and in *Conjunction* the 16th, at Four in the *Morning*. Then if you turn to the *Moon's Latitude*, you'll find the *Moon*, the 15th Day, when 'tis in *Apogee*, and very near *Conjunction*, to have Five Degrees of *Southern Latitude*; and therefore 'twill then be Five Degrees farther from us, who live in the *Northern Part* of the *Earth*, than the *Equator*, or 5 Deg. beyond the *Equator*. Then if you look to the First Day of the *Month*, where 'tis in *Conjunction*, and likewise *Perigee*, you will find it 4 Deg. 56' in its *Northern Latitude*; and consequently so much of this Side, or Nearer to us, than the *Equator*. Which being Added together, will be 10 Degrees within $\frac{1}{4}$, nearer to us in *Perigee*, and *Opposition*, than in its *Apogee*, and *Conjunction*. Then if you turn to *November*, you will find the *Moon* at Full, or in *Opposition to the Sun*, the 23d Day, and in *Apogee* at the same time: and *New Moon* the 8th, and *Perigee* the 7th. Then if you look upon the *Moon's Latitude*, the 23d Day, when 'tis at the Full, you will find it to be 3 Deg. 8' in its *Southern Latitude*, and the 7th Day where 'tis in *Conjunction*, and likewise *Perigee*, you will find it 4 Deg. 8'. *North Latitude*, which being Added, will be 7 Deg. 16'. nearer to us, when in *Conjunction*, than when in *Opposition*. So that 'tis sometimes *Perigee*, sometimes *Apogee*, when it is in *Conjunction*: and the same when 'tis in *Opposition*; and so in all other Parts of its *Orb*. And if you'll take the Pains to look all the *Year* throughout, you will find the *Moon* always *Perigee*, in its *Northern Latitude*, and always *Apogee* in its *Southern Latitude*; which shews the Truth of my Assertion.

3dly, Because the *Moon*, by reason of the Force of the *Sun's Rays*, Descends towards the *Earth*, when 'tis in *Conjunction* with the *Sun*; it may be supposed that its *Western Point* will Dip, as it Descends, and rise again when it Ascends. Which will Cause that *Libratory Motion*, from East to West, as *Tycho* observes at the Time of the *Syzygies*.

4thly, As to its *Latitude*, it cannot be supposed, but a *Body* so much Exposed to the Violence of the *Sun's Rays*, must be forced to *Decline* sometimes More, sometimes Less, from the *Equator*: besides its own *Inclination* by reason of the Inequalities of its *Surface*, as it Floats upon the Rapid Current of *Aireal Particles*.

5thly, That in every *Lunation* (or Time betwixt *Change* and *Change*) it has divers *Phases*, or *Appearances*: as in its Encrease it Appears *Horned*, or something resembling the Form of a *Sicle*. Afterwards it Appears *Halfed*, or as it were Cut in Two. Afterwards *Gibbous* or Bunching out of both Sides. After that at *Full*: From whence it Decreases, and becomes *Gibbous*, *Halfed*, and *Horned*, as it Encreased before.

And that it does sometimes, suffer a *Total Eclipse*; but oftner a *Partial*; and both, only when 'tis in the *Full*; and yet not in every *Full* neither, but for the most part once in six *Months*, and sometimes in Four. All which are very well Accounted for, by *Gassendus*, and Exactly according to our *Hypothesis*. And therefore I shall refer the Reader thither.

C H A P. XIX.

AS to *Venus* and *Mercury*, 'tis observed that they Constantly Accompany the *Sun*, and are carried in an *Epicycle* about it, as the Centre of their Motion. For which reason, their *Phænomena* are very much different from those of the *Superior Planets*.

First, Because they scarce ever go farther than Half a *Sign* from the *Sun* : whereas the *Superior Planets*, in the *Perigee* of their *Orbs*, are in *Opposition* to the *Sun*, and in the *Apogee*, are in *Conjunction* with him : but these both in *Apogee*, and *Perigee*, are in *Conjunction* with the *Sun*.

2dly, Sometimes they follow the *Sun*, and Set after it ; then disappear, and after some Time Rise before it, and go before it. Yea,

3dly, They are sometimes *Direct*, sometimes *Retrograde*, and sometimes *Stationary*.

4thly, Their *Degression*, or *Departure North*, and *South*, are sometimes Greater, and sometimes Less, than that of the *Sun*.

5thly, The *Orbit* of *Mercury* is Included within the *Orbit* of *Venus*.

6thly, They are sometime Above, and sometimes Beneath the *Sun* ; and sometimes Higher, and sometimes Lower than each other.

7thly, They borrow their Light from the *Sun*, and have the same *Phases*, as the *Moon*.

These *Phænomena*, are easily Accounted for supposing *Venus* and *Mercury* to be (as has been proved) the *Sun's* *Satellites* ; and that the *Satellites*

Satellites are *Light Bodies*. As may be supposed, because they are not able of themselves, to Dart down the *Ætherial Particles*, so as to give Light to us, composed of such *Similar Particles* with their own *Planets*. That they have always such a *Tendency* towards them, that they can never Depart far from them; and yet by reason of the *Impulse* of the *Particles* that immediately Circumvolve the Bodies of the *Planets*, can never Approach to them. But must therefore constantly keep company with them, at a certain Distance, in their *Course* from *East* to *West*, and every where about their own Orb: for *Similar Particles*, have *Similar Operations*; and consequently can never Act upon each other. But by the *Resistance* of those that are *Heterogenous*, will be forced together, and to *Unite*. And so I conceive the *Satellites* being *Similar Bodies* to their own *Planets*, have a *Tendency* towards them; being Forced that way by the *Impulse* of the more *Heterogenous*, or *Nitrous Particles* in the *Ætherial Fluid*: which drives them on, till they are Repercussed by an Equal *Resistance*. As by a Great *Wind*, arising from those *Ætherial Particles*, that are darted from the *Bodies* of the *Planets*, and put into Agitation by the *Rotation* of the *Planets* upon their own *Axis*: Where they are Fixt in a Constant *Circulation* about them, at such a Distance, and in such a Manner, as those *Bodies*, that by reason of a violent *Motion* are said to *Centrifuge*.

2dly, Because the *Sun* is known to turn upon its own *Axis*, it must be presumed that those *Particles* which are *Near*, or contiguous to it, will be put into a Gyration round about it: and consequently must strike hard upon the *Satellites*, as they follow it, upon the one Side that is Exposed

fed to them. As upon *Mercury* betwixt it and *i*, (in *Fig. p. 89.*) and give Way to it, as they Fly before on the other Side, betwixt *Mercury* and *l*. Which stronger *Impulse*, on one side of *Mercury*, than it has of the other, will put it likewise (and the rest of the *Satellites*) in a *Motion* the same Way about their own *Planets*, but something *Slower* : And that *slowest*, that is at the greatest Distance from the *Planet* ; those *Particles* there, having the Least Force upon it.

3dly, Supposing the *Satellites*, for these Reasons, to *Move* about the *Bodies* of their *Planets*, they must be sometimes *Direct*, or seem to *Move* according to the *Order* of the *Signs* ; When they *Move* strait forwards from the Place where they set out. Sometimes *Retrograde*, or *Contrary* to the *Order* of the *Signs* ; When they come Back again the other way ; as they must sometimes seem to do : because they *Move* about a *Globular Body* in an *Epicycle*, that is at a Distance from us.

And sometimes *Stationary*, when they seem to *Move* strait in a *Line* either Towards us, or From us.

4thly, Their *Digressions*, *North* and *South*, must be sometimes *Greater*, sometimes *Lesser*, than those of their *Planets* : Because they constantly keep company with 'em, and *Move* about 'em, even in their *Greatest Latitudes*.

5thly, The *Orbit* of *Mercury* is included in that of *Venus* : First, Because his *Greatest Digression* from the *Sun*, is *Less* than that of *Venus*.

2dly, Because he being *Nearer* the *Sun*, is of a more *Lively* brightness than either *Venus*, or any other *Star*.

3dly, Because as 'tis Nearer, so it Finish-
es its *Course* Quicker : for as 'tis Nearer, so its
Course is Shorter, and the *Force* of the *Parti-*
cles Circulating about the *Sun* is there stronger,
which must consequently *Move* it as much Faster
as 'tis Nearer.

6thly, Because, 'tis the *Force* of those Circu-
lating *Particles* about the *Sun*, that gives that
Motion to *Venus* and *Mercury*, and the *Circum-*
gyration of the *Sun* about its own *Axis*, that
gives *Motion* to those *Particles* : It is plain that
those *Bodies*, that are *Moved* by them, will be
carried along with them, in the same Manner,
or Way that they are carried about the *Sun*.
And because the *Motion* of the *Sun* about its own
Axis, is *Oblique*, or Declines from the *Plane* of
the *Ecliptic*, theirs will be so too ; and then be-
cause they *Move Oblique* about the *Sun*, they will
seem to be sometimes *Above*, and sometimes *Be-*
low the *Sun*. And because they do not Exactly
keep the same Pace with One another, about the
Sun ; *Venus* Moving slower than *Mercury*, they
will be sometimes *Higher*, sometimes *Lower* than
each other. For when *Venus* is in *Apogee*, and
Mars in his *Perigee*, then he is *Below* her ; when
Venus is in her *Perigee*, and *Mars* in his *Apogee*,
then she is *Below* him.

7thly, Because *Venus* and *Mercury* are some-
times *Above* the *Sun*, and sometimes *Below*, and
receive their Light from the *Sun*, they will ap-
pear to us to have the same *Phases* as the *Moon* ;
sometimes *Corniculated*, or in the Form of a
Crescent ; sometimes Half, and sometimes Full, as
that Part that is *Illuminated*, by the *Sun* is More
or Less turned towards us : only with this diffe-
rence, that when they are *Corniculated*, or to us
least *Illuminated*, then they seem by the *Tele-*
scope

scope Biggest, and Nearest to us; when they are in the *Full* they seem Least to us, Farthest from us, and in *Conjunction* with the *Sun*. By which last *Phænomenon* 'tis manifest they *Move* about the *Sun*; sometimes farther from us, and sometimes nearer to us, than he is; and consequently, the *Ptolomaic Hypothesis* in relation to these Two *Stars* cannot be true: Nor is it very consistent with the *Copernican*. For if they did *Move* Directly beyond the *Sun*, so that when they were in *Conjunction*, to be Directly in the *Sun's Zenith*, or in a Strait Line with the *Sun*, and the *Plane* of the *Ecliptic*, they could never appear in the *Full* to us, according to *Philip Lansbergius*, who makes the *Sun*, (*Gassendi Astronom. Page 165.*) to be 434 Times as Big as the *Earth*, and the *Sun's* Distance from the *Earth* to be 1500 of the *Earth's Semidiameters*, which is but 750 of the *Earth's Diameters*; so that the *Diameter* of the *Sun* will make so great an Angle with the *Earth*, and then *Venus* and *Mercury* must *Move* a great Part of its *Orb*, from the Place of *Conjunction*, before it will be so far separated from the *Rays* of the *Sun*, as to be visible to us; and consequently can never Appear in the *Full*. But supposing them to *Move* Obliquely about the *Sun*; when they are in their Greatest *Southern Latitude* above the Apparent *Diameter* of the *Sun*, that Part of them that is Illuminated by the *Sun*, will be Directly Opposite to us in the Northern Part of the *World*, and consequently at *Full*.

C H A P. XX.

AS to the *Fixed Stars*, their *Motion* always seem to be *Uniform*, and *Simple* : having no other *Motion* than from *East* to *West*, which they constantly perform in the same Time, tho' they may seem to have several others ; as

First, That of *Libration* from *East* to *West*, and from *North* to *South*.

2dly, A *Motion* like the *Planets*, into the consequent *Signs*.

3dly, A *Motion* of *Scyntillation*.

That *Libratory Motion*, I take to be in the *Earth*, tho' it seems to us, who always suppose our selves to stand still in the same Place, to be in the *Fixed Stars*. But that the *Earth* has such a *Motion*, from *East* to *West*, and from *North* to *South*, may be supposed : *First*, because its near Neighbour the *Moon* has such a *Motion*, which probably may give such an Impress to the *Air* under it, upon which the *Earth* Floates, that may Incline it, to such a *Motion* also.

2dly, Because the *Earth*, as 'tis a *Globe*, is Composed of Two *Parts*, One Lighter than another, and consequently cannot be Equally Acted upon by the *Solar Particles*, the Lighter Part of a *Globular Body* being easier Moved, than the Heavier. And therefore the same *Force* will make the Lighter, move faster, and turn about the Heavier, and Force it to Deflect from a *Strait Line* : As the Lighter Part of a Bowl does about the Heavier, or Byas, for the same Reason

son ; as is manifest, because you make it stronger, that is Deflect More or Less as you add more or Less *Wax*, or Weight to it. And as the *Sun* Moves sometimes on this, sometimes on the other side the *Equator* ; so by its *Pressure* on this Part of the *Earth*, it may alter its *Poise*, and Byas it towards the *North-West*, or Cause it to Move Obliquely in its *Western Motion* towards the *North* : But when on the other side the *Equator*, it may drive it back again to the *South-East*, by giving a Greater Force upon the Contrary Shores.

And this *Motion* of the *Earth*, possibly may be the Cause of Two or other *Phænomena* : For as its *Poles* Librate *Eastward*, or *Westward*, from the *Polar Stars* ; so it may Cause a *Variation*, or at least the Irregularity in the *Variation Eastward*, or *Westward* of the *Magnetic Needle*.

2dly, When the *Earth*, by its *Libration*, Moves *Westwardly* (I do not mean in its *Orbit*,) but upon its own *Axis*, getting a little *Westward* before the *Sun* : The *Sun* will be longer before it can Run round it, and come to the same Point again. Because the *Earth* Moving before it, will have Moved that Point something farther from it. On the contrary, when the *Earth* by its *Libratory Motion*, Moves *Eastward*, then it meets the *Sun* ; and consequently brings that Point something sooner to it. And it may be for this Reason, that the *Natural Day*, or 24 Hours are sometimes Longer, sometimes Shorter in One Time of the *Year*, than another.

2dly, As to the *Motion* of the *Fixt Stars*, into the Consequent *Signs* ; possibly it may proceed from those odd *Minutes* in the *Annual Computation*, which makes a *Day's* Difference in 100 Years

Years, betwixt the Julian, and Gregorian Account, or

2dly, It may be from the Alteration of the *Earth, and Seas*: The *Seas* getting Ground in some Places, and loosing it in others, as has bin sufficiently proved by Mr. Ray. And there is another *Learned Writer*, that has made our *Kingdom* almost all *Seas*, even to *Oxford*. This may alter the *Earth's* Poise, and thereby *Move* it a little, so as to make the *Fixt Stars* seem more in the *Consequent Signs*.

3dly, The cause of the *Scyntillation* of the *Fixt Stars*: I conceive is this, That they do not like the *Sun*, and the rest of the *Planets*, dart the *Ætherial Particles* in *Direct Lines*, to the *Earth, or Centre*; because the *Ætherial Particles* do not bear the *Weight* of their *Bodies* (as they do those of the *Planets*,) they being *Fixed* in the *Solid Orb*, and *Circulating* with it: They can only strike the *Ætherial Particles* down *Obliquely* by the sides of the *Firmament*, as they fall upon them in their *Circulation*, from *East to West*. So that the *Ætherial Particles* cannot come to us, but by various *Refractions*, as they pass thro' various *Mediums*, betwixt the *Firmament*, and the *Centre*. And because in so doing they must Rise from an *Oblique, or Crooked*, to a *Direct or Straight Line*, when they strike the *Eye*, they seem to be in a *Waving or Vibrating Motion*, which we call *Scyntillation*.

As for those *New Stars*, I am inclined to agree with *Ricciolus*, who says they are *Globes*, or *Bodies* that have but one side *Bright, or Shining*, and the other *Obscure, and Dark*. But then I conceive that these, and possibly some of the other *Stars*, do sometimes *Stick*, and sometimes *Slide* along the side of the *Solid Orb*, or *Firma-*

ment, (as those *Protuberances* which are of the same Nature, as those upon the Body of the *Sun* do :) And if as they Glide in the Concave of the *Firmament*, they strike against the Edge of another *Star*, or *Protuberance* in the *Solid Orb*, they may thereby have their *Bright*, and *Polished* side turned up, which may then seem a *New Star*, whilst it continues in that Posture; which afterwards being removed from thence may disappear.

Lastly, That Admirable Theorem of *Kepler*, wherein he shews that the *Periodical Times* of the *Planets* (as likewise of the *Satellites*) compared with One another, have the Proportion of One and a Half, with respect to their *Middle Distances* from the Centre about which they Move, that is, a Proportion of a Single Proportion, and Half as much more: Or which is the same Thing, the *Squares* of their *Periodical Times*, are as the *Cubes* of their *Middle Distances*. And this holds, as well in our *Hypothesis*, as any other, Particularly that of *Copernicus*.

For if it be true in *Venus*, and *Mercury*, according to his *Hypothesis*, it is true in ours, who make them to Move about the *Sun* as he does; (and the Rest of the *Satellites* about their appropriate *Planets* :) If it be true when the *Earth*, and Three *Superior Planets* Move in the same Place, and at the same Distance about the *Sun*, as their Centre; it will be likewise true, when the *Sun* and the Three *Superiour Planets*, Move in the same Place, and at the same Distance about the *Earth*, as their Centre, &c.

Which *Phænomenon* seems to have these *Physical* Reasons; First, as the *Medium* is Rarer, so the *Celestial Bodies* posited therein Move Faster as has bin shewed. 2dly, As they are farther from the *Movent*, so they will Move Slower because

because the *Movent* has less Force at a Distance, than it has near it. And therefore the Superior *Planets*, that derive their *Motion* from the *Fixed Stars* or *Firmament*, Move faster along with it, from *East* to *West*, as they are nearer to it. Because they are lighter *Bodies*, placed in a Rarer *Medium*, where the *Movent* has greater Force; but then their *Periodical Motion* will be Slower, because they keep a nearer Pace with the *Fixed Stars*, (as has bin shewed above;) and because there is a Gradual Encrease of Rarity, from the *Centre* to the *Firmament*. And the *Caelestial Bodies* have Gravity in Proportion to the *Density*, or Distance of the *Orb* they Float upon; their *Periodical Motion* will be Slower as they are Farther from the *Center*, in a Just Proportion: Which Proportion possibly is that above observed, The *Satellites* do not derive their *Motion* from the *Fixed Stars*, but from the Rotation of their *Planet* upon its own *Axis*, (as above :) And therefore they Move slower as they are farther from their *Planet*, and in different Lines from the *Plane* of the *Ecliptic*, in Proportion to the Obliquity of the *Axis*, upon which their *Planet* turns.

C H A P. XXI.

TO Answer that Great Objection, which Alienates so many from this *Hypothesis*, viz. that Incredible *Celerity*, that those Vast *Bodies* must Move with, that go so vast a Circuit, in short a Time, viz: in 24 *Hours*, I need say

no more, but that He that made the *World*, could have made them *Move*, as many Times swifter than they do now; as they now *Move* swifter than the *Wheels* of a *Pocket Watch*, with as much ease as He made the least *Particle* in the *World*. But those that consider that the *Mixtion* of different *Particles*, is the *Cause* of the *Generation*, *Life*, and *Corruption* of all things, and these *Motions*, the *Cause* of *Mixtion*; must grant, that the *Generation*, *Conservation*, and *Changes* of those *Indefinite Species*, or *Products* of this *Inferior World*, cannot be performed without inconceivable *Motions*, if there were no other. But it may likewise be supposed that the *Celestial Bodies*, are *Inhabited* with *Creatures*, that are *Generated*, and *Conserved*, from the same *Causes*, (but of what *Nature* they are of, we cannot guess any more than this, that they are *Bodies*, that can no more *Live* with us, than we can in *Water*; nor we with them, than *Fish* in the *Air*.) And it may be, before *Harvie* found out the *Circulation* of the *Blood*, it would have bin as great an *Amasement*, to have said that all the *Blood* in the *Body* of a *Man*, passes thro' his *Heart* in *Three* or *Four Minutes*; as now to say, that *Vast Body* of the *Planet Saturn*, goes as far in *24 Hours*, as a *Bullet*, if continued in the same swiftness as 'tis discharged from a *Great Gun*, would in *1500 Years*.

These Things indeed are *Surprizing*; especially to those that will not be at the *Pains* to consult their *Reason*: But condemn all Things for *Whims*, that are not *Subject* to the *Senses*.

But we should consider, that as the *World* was made by an *Infinite Workman*, so 'tis next to *Infinite* in all its *Parts*. Tho' we are so framed that only *Mean Things* affect our *Senses*, which

which we usually judge of all the rest. But if we make a *Rational Examen* into it, (tho' we can talk in the gross without considering what we say,) of *Infinite Magnitude*, *Infinite Celerity*, *Infinite Divisibility*, &c. yet if we come upon the Detail, we shall find there are *Actual Bodies* in the Universe, which very much exceed even our *Conceptions*, as to *Magnitude*, and *Smallness*, *Celerity*, and *Slowness*. For if *Sirius* (or the *Dog Star*,) be placed at so vast a Distance, that a *Cannon Bullet* (which Moves with the Greatest Celerity of any Thing we are acquainted with,) would be near *Seven Hundred Thousand Years* in coming from thence to us; (as has bin Demonstrated by Mr. *Hugens*,) which is but the *Semidiameter* of its *Orb*: With what incredible Celerity, must that *Star* of it self Move, that goes above Six Times as far, in 24 Hours. Yet this would be no great Wonder, if we considered that we are Daily conversant with the *Bodies*, that Move 20 Times faster than *Sirius*, (granting it to go this Circuit in 24 Hours,) as the *Luminous Particles*, that flow from the Body of that *Star* do; if they keep a *Proportional Swiftmess*, to the Celerity of that *Star*, compared to that of *Saturn*. For I am inclined to think, that the *Lucid Particles*, are as long in coming from the *Sun*, as from *Saturn*; and from *Saturn*, as from the *Fixt Stars*. For as the *Stars* are farther off, so their Celerity is greater; they Moving in the same or less time Round a greater *Orb*; and consequently must strike the *Ætherial Particles*, with a Proportionable greater Force. Which in those Regions are likewise more *Elastic*, being more *Rare*; and consequently their *Motion*, should be Accelerated, in Proportion to the Stroke of the Planet,

and the *Elasticity* of the Particle: And then the *Swiftness* of the *Luminous Particles*, must be encreased, as the *Orb* is Encreased, on which the *Planet* Moves; and therefore their Motion, from them to us, must be in the same Time. But however that is, from the Emerging, and Im-merging of *Saturn's Satellites*, (which I conceive results from the various *Phases* of those Bodies, as their *Illuminated Part* is turned towards us, and sometimes from their frequent *Eclipses* with each other,) it has bin *Demonstrated* by Mr. *Newton*, and others, that the *Light* flies from those Bodies to us in Ten Minutes, which is the *Semidiameter* of *Saturn's Orb*. And consequently, if their Course were continued, they would Move as far in One Hour, as *Saturn* does in 24, which moves as far in 24 Hours, as a *Cannon Bullet* would in 1500 Years. And therefore the incredible *Celerity* of those vast Bodies, (*viz.*) of the *Planets* and *Fixt Stars*, can be no Objection, to those who grant that the *Luminous Particles* move above 20 times Faster; as most of those who maintain the *Copernican Hypothesis*, and make this an Objection against the *Ptolomaic* do :) For the *Motions*, and *Celerity* of those vast Bodies, is much more Conceivable, and easier Accounted for, than of these *Minute Ones*.

Secondly, that Body must be of an Incredible *Magnitude*, that can be apparent to us, at so vast a Distance, that the *Celerity* of a *Cannon Bullet*, would be near 700000 Years in travelling over to us, as Mr. *Hugens* proves the *Fixt Stars* to be. Thus, seeing then (says he) that the *Stars* are 'so many *Suns*, if we do but suppose One of them Equal to ours; it will follow, that its Distance from us, is as much greater than that

of the *Sun*, as its Apparent Diameter, is less
 than the Diameter of the *Sun*. But the *Fixt*
Stars, even those of the First Magnitude,
 tho' viewed thro' a *Telescope*, are so very small,
 that they seem so many shining Points, with-
 out any perceivable Breadth; so that such Ob-
 servation can here do us no good. I saw this
 would not succeed, I studied, by what way I
 could so lessen the *Diameter* of the *Sun*, as to
 make it not appear Larger than the *Dog*, or
 any other of the Chief *Stars*. To this Purpose,
 I closed One end of my 12 Foot *Tube*, with a
 very thin Plate, in the Middle of which, I
 made a Hole, not exceeding the Twelfth Part
 of a *Line*, i. e. 144 Part of an *Inch*; that end
 I turn to the *Sun*, placing my Eye at the other,
 I could see so much of the *Sun*, as was in Dia-
 meter about the 182 Part of the whole: But
 still that little Piece of him, was Brighter much
 than the *Dog-Star*, is in the clearest Night. I
 saw that this would not do; but that I must
 Lessen the Diameter of the *Sun* a great deal
 more: I made then such another Hole in a
 Plate, and against it, I placed a little Round
 Glass, that I had made use of in my *Microscop*
es, of much about the same Diameter with
 the former Hole. Then looking again towards
 the *Sun*, taking care that no Light should come
 near my Eye, that might hinder my Observa-
 tion:) I found it appeared of much the same
 clearness as *Sirius*. But casting up my Ac-
 counts according to the *Rules of Dioptrics*, I
 found his Diameter now was but $\frac{1}{182}$ Part of
 that $\frac{1}{182}$ Part of his Whole Diameter, that I
 saw thro' the former Hole. Multiplying $\frac{1}{182}$ and
 $\frac{1}{182}$ into one another, the Product I found, to
 be 27664, the *Sun* being therefore Contracted
 K 4 into

' into such a Compass, or being Removed so far
 ' from us, (for it is the same thing,) as to
 ' make its Diameter, but the 27664 part of that
 ' we every Day see, will send us just the same
 ' Light as the *Dog-Star* now does. And his Di-
 ' stance then from us, will be to his present
 ' Distance, undoubtedly as 27664. is to 1 :
 ' and his *Diameter*, little above 4 m. Seeing
 ' then, *Sirius* is supposed equal to the *Sun*, it
 ' follows that its Diameter, is likewise 4 m,
 ' and that his Distance, to the Distance of the
 ' *Sun* from us, is as 27664 to 1. And what an
 ' Incredible Distance that is, will appear by the
 ' same way of Arguing, that we used in Measuring
 ' that of the *Sun* : For if 25 Years are required
 ' for a Bullet out of a Cannon, with its utmost
 ' Swiftnes, to Travail from the *Sun* to us,
 ' (supposing the Bullet to Fly a Hundredth Fa-
 ' thom in the *Pulse* of an Artery, as is proved
 ' by those Experiments, that *Mersennus* in a
 ' Treatise of his, relates ; wherein Sound was
 ' found to extend it self Eighty Hundred Parts
 ' in that Time.) I say then, that supposing a
 ' Bullet to Move with this Swiftnes, from the
 ' *Earth* to the *Sun*, it would spend 25 Years
 ' in its Passage : The *Earth* being 12000 of its
 ' Semidiameters distant from the *Sun*, (as he
 ' has proved above.) Then, by Multiplying the
 ' number 27664 into 25 ; we shall find, that
 ' such a Bullet, would spend almost *Seven Hun-*
 ' *dred Thousand Years*, in its Journeying between
 ' us, and the nearest of the *Fixed Stars*.

This is *Demonstration*, if the first Supposition
 be True, viz. that *Sirius* is as Big as the *Sun*.
 And that it is, may be proved by Arguing in
 the same manner as Mr. *Hugens* does. For the
Fixt Stars are at so great a Distance, that the

best

best of our *Telescope*, tho' 120, or 200 Feet long, will not in the least *Magnifie* them: Yet the Planet *Saturn*, being viewed thro' them, will appear as Big as the *Moon*. From whence, we may certainly conclude, that they are as many Times farther from us, than *Saturn*, as the Apparent Body of the *Moon* is Bigger than the Apparent Body of *Saturn*: or as the Body of *Saturn*, viewed thro' a *Telescope*, is bigger, than when viewed by the Naked Eye. For if they were not, they would suffer themselves to be *Magnified* as well as *Saturn*; which I suppose, will be more than Equal to that of the *Sun*.

But it may be further Argued, that the *Fixt Stars* are as many times farther from us, than *Saturn*, as *Saturn* viewed thro' a *Telescope*, is bigger than *Sirius*; or any other *Fixt Star* viewed thro' the same *Telescope*. Which latter the *Telescope* is so far from Magnifying, that by shading them from their Fictitious Rays, it makes them appear much less; just like little shining points, without any perceivable Breadth: which if then measured according to M. *Hugens* his Method, would yet appear much more Distant; and therefore they must be much bigger than the *Sun*. But then of what inconceivable Magnitude must the *Solidum Expansum*, or *Firmament* be of, that contains an Indefinite Number of such *Stars* in its *Concave Superfices*.

On the other hand, Mr. *Leewenhoeck* has observed *Vessels* in the *Brain*, so small, that if a Grain of Sand, were divided into Ten Hundred Thousand Parts, and soft and yielding as a Globule of blood, they would be too big, to enter those *Vessels*. And yet there are Bodies in the *Air*, so small, that they can go thro' the Pores in the sides of those *Vessels* filled with a Juice Proportional

tional to them; or thro' the Pores of *Gold*, or *Silver*, or any other the most Compact Body, with as much ease, as a Man can go thro' an ordinary Door. And this is evident from the *Effects* that a *Loadstone* will have upon a *Mariner's Needle*, thro' a *Man's Head*, or any other Body.

The same *Lenwenhoeck* has observed, Threads of a Young *Spiders* Spinning, so small, that 400000 of them, are not so big, as the Hair of ones Head, *Philos. Transac. Num. 271. p. 878.*

He has likewise observed *Animals* in the *Sperm* of small *Insects*, to be a *Thousand Millions* of Times smaller than a Great Sand. *Philos. Transac. Num. 279. pag. 1142.* Of what Smallness then, must the *Vessels* be, and the *Particles* of those Juices, that Circulate in them, in those *Animals*.

Mr. Boyle gives an Account of a Motion so Slow, that it cannot be perceived to Move, a Hairs Breadth in 80 Years. He instances a *Violin*; which is known to shrink so long, (tho' Imperceptibly) because comes not to its True Sound in less Time.

These Things, tho' *Matters of Fact*, and capable of *Demonstration*; do even Exceed our Conceptions. As is evident, by their being Rejected by all Mankind, as *Chimeras*, and *Fabulous*, when First Proposed, Which proceeds from a Weakness of *Spirit* in Us; who think there is nothing in *Nature*, but in that one Way, and in that one Degree, that we are used to. And indeed 'tis a strange Power that Custom has upon Weak and Little Spirits, whose *Thoughts* reach no farther than their *Senses*; who make that which they have bin accustomed to, the *Standard* and *Measure* of *Nature*, of *Reason*, and *Religion*: this is evident by the Prejudice of Education, which generally Fixes things so strong in the *Imagination*.

ons of Men, that there is no Moving of them, tho' never so Weak and Ridiculous. Neither are there any sort of Men, more Positive and Tenacious, or more Peevish in maintaining their Opinions, or more Cenforious of Others; than those that heave the least Evidence of the Truth of their own: as is easily and usually observed.

CH A P. XXII.

HAVING established the *Principles*, and Accounted for the *Motions* of the Celestial Bodies, and their Positions. Next we are to consider the *Phænomena* that result from their Actions upon each other; and all Compound Bodies, (as they are such as above described.) And endeavour to Confirm our *Hypothesis*, by the Solution of their several Operations and Appearances in the Universe.

And First, We will consider the Operation, or Power of the *Ætherial Particles*, as they are Darted from the Celestial Bodies, *viz.* from the *Sun*, *Moon*, &c. And First, As these *Particles* darted from the *Sun* have Power to Rarify, and Dilate the Atmosphere, and Cause it to Press hard upon the Earth. 2dly, As they are *Elastic*. 3dly, As they are contrary to the *Nitrous*, or *Acid* Particles of the *Air*. 4thly, As they have Rotation upon their own *Axis*.

First, By their Activity, or by their Expansive Spring, and Violent Rotation above mentioned; they Dilate our *Atmosphere*, and Cause it to Press hard upon the *Earth* and *Seas*: and so they are the Cause of the *Diurnal Motion* of the *Earth*, has bin shewn.

2dly,

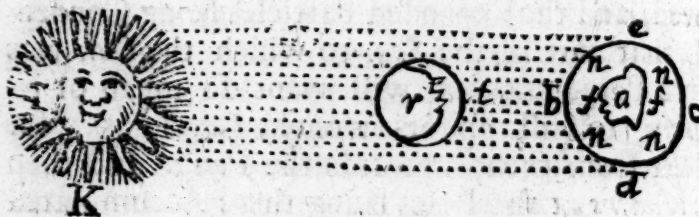
2dly, Of its *Libratory* Motions, as has bin likewise shewn.

3dly, They are the Cause of the *Ebbing*, and *Flowing of the Sea* : which comes to pass. *First*, By their *Luftation* with the *Watry* Particles, and their *Rarifaction* of them. 2dly, By the *Expansion* of the *Aerial Particles* contained in the Pores of the *Water*. By both which, the *Seas* must necessarily be *Dilated*, and *Caused* to *Swell* and *Rise* higher, in that Part that these *Particles* are *Perpendicular* to ; for that the *Solar Particles* are capable of *Dilating Water*, or any other *Fluid* is certain : Besides what has bin said already, is evident by the *Rising* of the *Thermometer* in the *Day Time*, caused by the *Presence*, *Operation*, or *Heat* of the *Solar Particles* : and its *Falling* again in the *Night Time*, when they are in some measure withdrawn. And *Seamen* are said to observe, that their *Ships* draw less *Water* in *Cold*, and *Frozen Countries* (tho' the *Water* is not in these *Places* so *Salt*,) than they do in *Warmer Places*. And the *Honourable R. Boyle* has observed *Water* to *Dilate*, and contract it self in the same *Day*, by an *Hermetic* *Glass Bubble*, that would *Sink* in *Water* at *Noon*, and *Rise* and *Swim* at *Night*, and *Morning*. By all which 'tis plain, that *Water* is *Denser* in *Cold*, than in *Warmer Places* and *Seasons*.

2dly, Because at the same time they *Rarify* the *Atmosphere*, and *Cause* it to take up more *Room* : and consequently make it *Press* harder upon that Part of the *Seas*, that is thus *Swelled* and *Raised* up higher. This *Pressure*, being added to the *Fluidity* of the *Water*, or to the *Pressure* of its own thus *Accumulated Particles*, (which being *Globular* like *Childrens Marbles*, would *Force* those upon the *Borders* to *Rowl* away, and

and Disperse to a greater Distance ; by which they will all sink down into a Level.) Both which Causes concurring (viz. their own Fluidity, and the Pressure of the *Atmosphere*, Rarified by the Presence of the *Sun*,) must necessarily drive the *Waters*, with violence towards the *Poles*; and Accumulate them there : which after they have continued there for some time, the Cause that drove them thither. viz. the *Sun*, being removed, and the Expanded Particles being Condensed, that part of the *Sea*, to which the *Sun* was before Perpendicular, will want so much of its *Waters*, to fill up its wonted Level, as were Forced from thence towards the *Poles*. And then the *Waters* at the *Poles* being there Accumulated beyond their Level, and Floating upon the Shoars, will for the same Cause, viz. their own Fluidity (or Propensity to Scatter and Fall into a Level,) roll back again to the Place they came from. But because they cannot go Forwards and Backwards in an Instant ; the Tendency of the *Waters* towards the *Poles* (like the Sway of a *Pendulum*) for sometime Resisting the Gravity of the *Water* in its Return ; it must for sometime be at a stand : and is usually about a Quarter of an Hour before it sensibly Returns, or makes the *Reflux*. Which after they are Returned, *Ebbs* for as long a time, before they Flow again. But because the *Sea Ebbs*, or *Flows* once in Six Hours : it will by this means lose almost an Hour, or about 50 Minutes in 24 Hours : or the Tide will be 50 Minutes later every Day than other. And because the *Moon* loseth much about the same time, every day from the *Sun* ; and consequently comes to be in Conjunction or Opposition with it once a Fortnight: the *Moon*, and Tide will nearly keep Pace with each other. Which is the Cause

Cause that the *Moon* has generally bin esteemed, to be the Cause of the *Ebbing*, and *Flowing* of the *Sea*; and it must be confest, as it Presses upon its Surface, as well as the *Sun*, so it must farther its *Motion* Proportionably. For if the *Ætherial Particles* darted from the *Sun*, have Power to rarify the Atmosphere, and make it Press harder upon the *Earth*, as has bin shewn; the same Par-



ticles Reflected from the Moon must have the same Effect, in a Proportion, Equal to the Number of these Particles so Reflected. Which will be most visible at *Full*, and *Change*; when it Presses much harder than at other Times. At *Full*, because then that Hemisphere of the *Moon*, that is Illuminated by the *Sun*, and consequently has its *Atmosphere* Rarified by the *Solar Particles*, is turned Directly upon us, which will likewise Rarify ours, and make it Press harder upon the *Seas*. So when in *Conjunction*, it being Directly under the *Sun*; the *Sun* by Pressing upon it, will Force it to Press hard upon the *Earth*, and by their United Forces, Cause a greater Tide, than in the *Neap-Tides*; when there is but a Part of the Illuminated Hemisphere of the *Moon* turned towards us.

Suppose the Figure to be the *Sun*, *Moon*, and *Terraqueous Globe*: *k* the *Sun*, *r* the *Moon*, the other the *Earth*. Of which *a*, is the *Poles*, *n n n n* the *Seas*, the Circle *b e c d*, the *Equinoctial*; in

in which the *Sun* and *Moon* move, Perpendicular to *d*. And that Part of the *Seas* that the *Sun* is Perpendicular to, to be Rarified; and thereby Accumulated, or swelled beyond its wonted Level; and at the same time more than usually Pressed upon by an *Atmosphere*, Dilated by the *Solar Particles*: it will follow, that the *Water* in those *Seas* at *d*, will be drove by their own Fluidity, and the more than ordinary Pressure of the *Atmosphere*, with Violence on both sides the *Equinoctial*, towards *a*, the *Poles*, and strait forward from *d*, towards *b*, as the *Sun* moves nearer to it. Which will Cause the Waters gradually for Six Hours to Rise at *f*, as the *Sun*, and *Moon* approach to *t*, the *Zenith* of *b*, which when they come to and are passing towards *e*, supposing *b*, to be *South West*, they will Force the *Waters*, rapidly to Ascend the Shores upon the Western Coasts, and among the rest to damn up the *River Thames*, and consequently to make *High-Water* at *London-Bridge*. Where 'twill remain, for sometime at a stand, till the *Sun*, and *Moon* are passed to some Distance towards *e*.

But then the *Waters*, being Raised upon the Shores much above their Due Level; they will gradually Descend, as they Ascended before towards *b*, the *Equinoctial*, for Six Hours more: by which Time the *Sun*, and *Moon* will be Perpendicular to *e*; and the *Waters* that Descended from the *Northern*, and *Southern* Shores, will meet at *b*, the *Equinoctial Line*. Where they will not immediately fall flat, but being Impelled by the pursuing Air, on both sides, and there Resisting each others Passage, like Two Streams meeting, will be Forced up there, to a Height almost equal to what they were on the Shores, from whence they Descended; in which Posture they cannot

cannot stay there neither, but after they have grappled for a Quarter of an *Hour*, will revert back again in Six *Hours*, to the same Place, and almost to the same Height to the *Shoars* at *f*. From whence they came. (like the sway of a *Pendulum*, or as *Water* moved so, as to make it Ascend one side of a *Basin*, or *Boat*, will of its own accord by Reason of its Fluidity revert, and Ascend almost as far on the Contrary.)

By which time the *Sun* and *Moon* will become *Perpendicular* to *e*, and make *High Water* at *i*, opposite to *f*, and within a Quarter of an *Hour* will revert back again, and in Six *Hours* come to *c*; as those at *f*, will to *b*, the *Equinoctial* Line. In which time the *Sun*, and *Moon* will be got to *d*, and by a Fresh Impulse will raise the *Waters* at *f*, and Encrease them, till the *Sun* and *Moon* come almost *Perpendicular* to *b*; at which time 'twill again make *High-Water* at *London Bridge*. And so for ever, the same Causes having the same Effects upon the same Bodies.

The one Tide, viz. that when the *Sun*, and *Moon* are South West, being always Higher on those Coasts, viz. at *London Bridge*; than the reverse, when the *Sun* and *Moon* are North East. The reverse being made only, by the Falling back of the *Waters* at the *Equinoctial*, purely upon the Account of their Fluidity, and not by the Pressure of the *Sun*.

When the *Sun*, and *Moon* are in Conjunction or Opposition in the *Equinoctial* Line, they will then Cause the Greatest Tides: because then the *Waters* are Equally divided, and Impelled at an equal Distance from the *Equinoctial*, towards the Poles. But when they are in the *Tropicks*, they Impel a lesser part of the *Waters*, towards one of the Poles; and a greater part with less Force, they

they then being at a Greater Distance towards the other unequally : And therefore they will then make lesser, but more equal *Spring* and *Neap-Tides*. Of the Two *Equinoctial Tides*, the *Spring* is the greatest, and soonest ; because then the *Sun* Approaches our *Northern Hemisphere* every day ; and therefore Gradually drives the *Seas* more violently towards our *Shores*. But in *Autumn*, when the *Sun* declines us, and its Tendency is towards the *Southern Hemisphere*, the *Seas* yielding to it, are impelled more violently that way : and therefore make the greatest *Equinoctial Tide* on that side, before it does on ours. Wherefore the greatest *Spring Tide* in *March*, is with us rather before the *Equinox*, and that in *September* rather after.

And as the *Spring Tides*, are greatest in *March*, and *September*, the *Sun*, and *Moon* being then in Opposition, or Conjunction in the *Equinoctial Line*, and by their *United Forces* make the greatest Effort upon the *Seas* : so the subsequent *Neap-Tides* are always the least ; being produced when the *Moon* is Declined from the *Equinoctial* to the *Tropics*. Whereas in *June* and *December*, the *Spring Tides* are made by the *Tropical Sun*, and *Moon*, and therefore less vigorous. And the *Neap-Tides*, when the *Moon* is reverted from the *Tropics* to the *Equinoctial*, which are therefore the stronger. Hence it happens that the difference between the *Spring* and *Neap Tides*, in these *Months*, is much less considerable than in *March* and *September*.

The Irregular *Tides* proceed from the Crossing, and Meeting of different *Seas* ; and from being bandied Backwards, and Forwards from different *Shores* ; as is observable in the *Islands of Orkney*, where the most Irregular *Tides* may be easily Ac-

counted for : if we observe the Situation that the Shores of those Islands have to one another, and *Sic de Cateris*.

The reason why the *Lakes*, and such as the *Caspian Sea*, the *Mediterranean*, the *Black-Sea*, and *Baltick Sea*, have no sensible *Tides*, is because *Lakes* having no communication with the *Ocean*, can neither Increase nor diminish their *Waters*, so as to make them Rise or Fall ; (especially beyond the *Tropics*, where they are in a great measure out of the *Sun's*, and *Moon's* Jurisdictions.) And *Seas* that communicate Narrow Inlets, as that of the *Streights*, *Baltic*, &c. and are of so Immense an Extent, cannot in a few *Hours* time Receive, or Empty *Water* enough to Raise, or Sink their Surface any thing Sensibly.

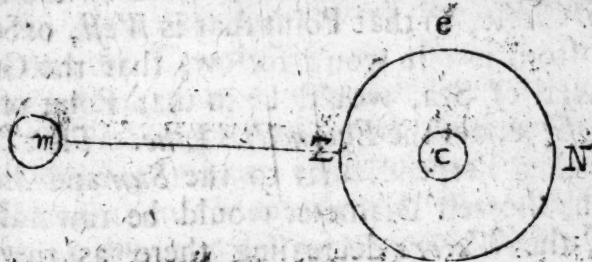
Thus, all the *Phænomena* of the *Ebbing*, and *Flowing of the Sea*, may be Fairly, and *Naturally* Solved by this *Hypothesis*. Yet I have the Mortification to find a very Great Man, Worthily esteemed an *Ornament* to his Country, Accounting for the same *Phænomena*, by an *Hypothesis* Diametrically contrary to This. For whereas, I make the *Pressure of the Atmosphere*, Rarified by the Presence of the *Sun*, and *Moon*, to be the Cause of the *Ebbing*, and *Flowing of the Sea* ; he says 'tis the *Attraction of the Sun*, and *Moon*, lessening the *Pressure* upon these *Seas* where they are *Vertical*, and consequently making there a Greater Swell of *Sea*, by the *Flowing* thither of the *Waters* from the Adjacent Parts. I must confess, I never read the Authors *Celebrated Book* my self, nor do I think (by what I have heard) myself *Mathematician* sufficient to Judge of it, if I did : but the Account that I have is Abstracted from His Book, Intituled, *Philosophiæ Naturalis Principia Mathematica*, by Mr. *Halley*, and is inserted in *Philos*

Transact

Transact. N. 226. 'Where he says, pag. 450, It being here demonstrated, that the *Sun*, and *Moon* have a like Principle of *Gravitation* towards their *Centres*, (meaning as the *Earth* has towards its *Centre*;) and that the *Earth* is within the Activity of their *Attractions*, it will plainly follow, that the Equality of the Pressure of *Gravity* towards the *Centre* will be thereby disturb'd; and tho' the smallness of their Forces, in respect of the Gravitation towards the *Earth's* *Centre*, renders them altogether imperceptible, by any Experiments we can devise, yet the Ocean being Fluid and Yielding to the least Force, by its Rising shews where it is less Pressed, and where 'tis more Pressed by its Sinking.

'Now if we suppose the Force of the *Moon's* Attraction to decrease as the Square of the Distance from its *Centre* increases, (as in the *Earth* and other Celestial Bodies,) we shall find, that where the *Moon* is Perpendicular either above or below the *Horizon*, either in *Zenith*, or *Nadir*, there the Force of Gravity is most of all diminished, and consequently that there the Ocean must necessarily swell, by the coming in of the Water from those Parts where the Pressure is greatest, viz. in those places where the *Moon* is near the *Horizon*.

'But that this may be better understood, I thought it needful to add the following Figure,



where *m* is the *Moon*, *e* the *Earth*, *c* its *Centre*,
L 2 'and

' and *Z* the place where the *Moon* is in the *Ze-*
 ' *nith*, *N* where in *Nadir*. Now by the Hypo-
 ' thesis 'tis evident, that the *Water* in *Z*, being
 ' nearer, is more Attracted by the *Moon* than the
 ' Centre of the Earth *c*, and that again more than
 ' the *Water* in *N*; wherefore the *Water* in *Z*,
 ' has a tendency towards the *Moon*, contrary to
 ' that of *Gravity*, being equal to the excess of
 ' the *Gravitation* in *Z*, above that in *c*: and in
 ' the other Case, the *Water* in *N*, tending less
 ' towards the *Moon* than the Centre *c*, will be
 ' less Pressed, by as much, as is the difference of
 ' the *Gravitations* towards the *Moon* in *c*, and *N*.
 ' This rightly understood, it follows plainly, that
 ' the *Sea*, which otherwise would be *Spherical*,
 ' upon the Pressure of the *Moon*, must form it
 ' self into a Spheroidal or Oval Figure, whose
 ' longest Diameter is where the *Moon* is Vertical,
 ' and shortest where she is in the *Horizon*; and
 ' that the *Moon* shifting her Position as she turns
 ' round the *Earth* once a Day, this Oval of *Wa-*
 ' *ter* shifts with her, occasioning thereby the Two
 ' *Floods*, and *Ebbs* observable in every Twenty-
 ' five Hours.

In answer to this, I say that if the *Moon* has
 such an *Attractive Faculty*, as to Cause the *Sea* to
 form it self into a Spheroidal, or Oval Figure,
 whose longest Diameter is where the *Moon* is ver-
 tical, and shortest where she is in the *Horizon*;
 supposing the *Sun*, and *Moon* to be in the *Equi-*
noctial Circle, in that Point that is *West*, or South
 West from us: it would follow, that the Great-
 est swell of *Sea*, would be in that Point of the
Compass, under the *Equinoctial Line*. That Point
 being then Perpendicular to the *Sun* and *Moon*:
 and the shortest Diameter would be towards the
Poles, the *Waters* decreasing there, as they en-
 crease

crease under the *Equinoctial Line*, whether they Flow to make up that Swell of Sea (or longest Diameter) in that Point that is Perpendicular to the *Moon*; and consequently we being placed beyond the *Tropics*, remote from the *Equinoctial*, must have lower Water at *Lundy*, and upon all our *Western Coasts*; the *Waters* being then sunk from thence to Flow towards the Line.

As suppose in the same *Figure*, *m* the *Moon*, *z e n* the *Equinoctial Circle* of the *Earth*, *c* the *North Pole*; 'tis plain the *Waters* would sink Equally from *c*, and *e*, they being Equidistant from that Point of the *Equinoctial*, where they make that Swell of Sea at *z*, and *n*; and then a West or South-West *Moon* would make Low Water upon these Coasts, which is contrary to what is Daily seen. And in the other Case, (he says,) The Water in *n*, tending least towards the *Moon*, than the Centre doth, will be less pressed, by as much as is the difference of the Gravitations towards the *Moon* in *c*, and *n*. But I cannot conceive how the *Waters* at *z*, being nearer, and therefore tending more towards the *Moon* should be less press'd, and therefore make a Greater Swell of Sea, in that Point; and on the contrary the *Waters* in *n*, tending Less towards the *Moon*, should be Less pressed also; and therefore make a Greater Swell of Sea there: For if the Gravity of the *Waters* at *z* towards the Centre, is lessened by the Attraction of the *Moon*, the Gravity of the *Waters* at *n* towards the Centre, by the *Moon's Attraction* being added to their own Tendency to the Centre, will be augmented, and therefore the Pressure will be Greater. Wherefore, if there be a Full Sea there, it cannot from this Cause be so at *n*, at the same Time, as according to Nature

it ought to be. For as the *Moon* at *m* is *Zenith* to *z*, so it makes a *Full Water* there, as *Nadir* to *n*, *High Water* there.

But if it be supposed that the *Waters* at *z*, being nearer to the *Moon*, and therefore more Attracted by it, may by that Attraction recede farther from their Natural Centre *c*; then the Centre *c*, being farther off that Attraction, and therefore less affected by it can follow; and the Centre *c*, should recede farther from the *Waters* at *n*, then the *Waters* at *n*, purely from this Cause, (*viz.* the *Moon's Attraction*.) can follow. Yet the Natural tendency of the *Waters* at *n*, towards their Centre *c*, will not be, by this at all diminished, but increased, in Proportion to the excess of the *Moons* Attraction of the *Waters* at *n*; inclining them the same way (towards *z*,) so much more than their Natural tendency to their Centre *c*; and consequently they must be so much the more pressed on that side, or have a greater tendency to the Centre *c*: And therefore make (according to his *Hypothesis*.) a lower *Water* there.

And this, Page 452. he seems to confirm, (where he says) 'It is also observed, that *ceteris paribus*, the *Equinoctial* Spring Tides in *March* or *September*, or near them, are the Highest, and the *Neap Tides* the lowest: Which proceeds from the greater Agitation of the *Waters*, when the Fluid *Spheroid* revolves about a great Circle of the *Earth*, than when it turns about in a lesser Circle; it being plain, that if the *Moon* were constituted in the Pole, and there Stood, that the *Spheroid* would have a fixt Position, and that it would be always *High-Water* under the Poles, and *Low Water* every where under the *Equinoctial*: And therefore

fore the nearer the *Moon* approaches the *Poles*, the less is the Agitation of the *Ocean*, which is of all the greatest, when the *Moon* is in the *Equinoctial*, or farthest distant from the *Poles*.

Now here He says, 'Tis plain that if the *Moon* were constituted in the *Pole*, and there stood, that the *Spheroid* would have a fixt Position, and that it would be always high Water under the *Poles*, and low Water every where under the *Equinoctial*. If this be True, the Reverse will be likewise True: That when 'tis High Water under the *Equinoctial* (or what according to His Hypothesis is Equivalent to it,) When the *Sun*, and *Moon* are in the *Equinoctial*, 'tis low Water in any Port, near the *Poles*, (or beyond the *Tropics*,) in the same *Meridian* that they are in. But this is contrary to Observation, an *Equinoctial Sun*, and *Moon*, giving that Impulse on the *Seas*, which makes the Highest Water under the *Poles*, in those Ports whose *Meridian* they are in, tho' it does not appear in the Ports, till they are something past.

2dly, If it be True as He affirms, That if the *Moon* were constituted in the *Pole* and there stood, that the *Spheroid* would have a fixt Position, and that it would always be High Water under that *Pole*: It must likewise follow, that the nearer the *Sun*, and *Moon* approach any Port, beyond the *Tropics*, or near the *Poles*, the Higher the Waters must be in those Parts: Because they will be more affected by the Waters Flowing to a Point, that is near them, by the Attraction of the *Sun*, and *Moon*, being there Vertical, than by their Flowing to a Point that is at a greater Distance: And consequently a *Tropical Sun*, and *Moon* would make a greater Flood with us than an *Equinoctial*: Which is contrary to Observation.

Neither would it help Him to say, that the *Highest Equinoctial Spring Tides*, proceed from a greater Agitation of the Waters, when the Fluid Spheroid revolves about a greater Circle of the Earth, than when it turns about in a lesser: For an Agitation made by *Attraction*, is neither greater nor lesser in one Place than another, (supposing it to be Equidistant,) as may be inferred from what He grants, *That if the Attracting Bodies were fixt in the Pole, they would always make high Water there, and low Water under the Equinoctial*; which shews their Power is alike in all Places. But granting that there should be a greater Agitation of the Waters, (as there is,) when the *Sun* and *Moon* move in the greatest Circle, viz. the *Equinoctial*, than when they Move in a lesser; yet the Tendency of the greater Agitation, would be according to Him, towards the *Equinoctial*, where they are Vertical; and consequently the Waters being then Highest there, would be Lowest with us.

But according to our *Hypothesis*, it may be Justly supposed, (for the Reasons above mentioned,) that there will be a greater Agitation of the Waters from the Pressure of the *Atmosphere*, when the *Sun*, and *Moon* move about the Earth in a great Circle, than when they Move in a lesser; by which they must Force the Seas with more Violence, and Equality towards the Poles: And consequently, then make the greatest *Spring Tides* with us; according to our Daily Observation.

And that the *Air* or *Atmosphere* is dilated by the Presence of the *Sun*, and *Moon*, and therefore does Press harder upon the Seas; may be farther Demonstrated, by the common Experiment of *Artificial Fountains*: Which is per-
formed

formed in this manner. Suppose the Figure to be a Glass Vessel, in whose Upper Orifice at A, the Tube *d*, with a very Narrow Cavity like that of a Tobacco-Pipe, is inserted, and descends to B the bottom of the Vessel or near it; the upper Orifice of the Vessel being so closed with



Wax, or otherwise at A, that neither *Air*, nor *Water* can get in or out any other way than thro' the Cavity of the Tube *d*: It being thus fixt, if you hold the Vessel to the Heat of the Fire, the Fiery Particles will so Rarifie the *Air* contained in the Vessel, as to make it take up more Room, and consequently will Force part of it out thro' the Tube *d*, into the open *Air* or *Atmosphere*. And then if you immediately put A, the upper Orifice of the Tube into Water, the *Spring* of the External *Air*, being stronger than the Internal Expanded, and consequently Weakned *Air* contained in the Vessel, will Force the Water, (as the Fiery Particles recede,) to Ascend thro' the Tube into the Vessel; so long till it has filled a Space, in the Vessel, Equivalent to the Evacuated

ed *Air*, before contained therein; and has thereby reduced that part of the *Air* that remained in the Vessel, to its wonted *Spring*, viz. equal to that of the External *Air*, which we'll suppose to be so much, as to fill the bottom of the Vessel to *c*, now if you Augment the strength of the *Spring of the Air*, contained in the Vessel betwixt *a*, and *c*, so as to make it stronger than that in the open *Atmosphere*: which may be done by blowing into it and so forcing more *Air* to be contained in the same Place, which will make the *Spring of the Internal Air*, thus Crowded and therefore more Contracted, Stronger than that of the *External*, and to press so hard upon the Surface of the *Water* at *c*, as to make it Spout out in a Stream, like that at *e*. And then if you again hold the Vessel to the Fire, or expose the Glass to the *Sun*, and direct its collected Rays into the Vessel with a *Burning-Glass*, the Fiery or *Solar Particles* will so Rarifie the *Internal Air*, contained in the Vessel betwixt *a* and *c*, as to make it Press so strong upon the Surface of the *Water* at *c*, as to Raise the *Water* with much more Force, and make the Spout Ascend much higher, as to *f*. I made the *Water* Ascend thro' the Tube, as oft as I directed the Rays of the *Sun*, with a *Concave Metallic Speculum*, to the Vessel, which would stop as oft as I took it away. The same effect of Heat is likewise manifest in the Ball of a *Water-Weather-Glass*; in which the *Air* being Rarified by the *Solar Particles*, or any other Heat, (as that of your Hand,) will Press so hard upon the Surface of the *Water* in the Tube, as to make it Visibly Descend.

Now

Now I think 'tis plain in this *Experiment*, that 'tis the *Rarifying Force* of the *Solar Particles*, that Caused the included *Air* to require more Space, and therefore to Press harder upon the Surface of the Water, and to drive it with more Violence thro' the Tube. And if so, it will follow by the same Rule that the *Sun* has Power, and when present does Rarifie the *Air*, or *Atmosphere*; and consequently makes it Press harder upon the *Seas*: Which is contrary to that of *Attraction*, which Mr. *Newton* asserts; which therefore cannot be True: because, *Contrary Effects, cannot proceed from the same Cause, Operating upon the same Body, in the same Manner, at the same Time.*

Now this *Phænomenon* could not proceed from *Attraction* of the *Sun*; for by *Attraction*, it would rather have Raised the Water higher in the Vessel, than have *Forced* it thorow the Tube, except it be alledged, that the interposition of the Vessel, might hinder the *Attractive Power* of the *Sun*, in many other Parts than that, that has communication with the open *Air*, in the Tube: but then there will be another difficulty, to shew how the *Water* was drawn into it before, what Power directed it thither, if not the *Pressure* of the *Atmosphere*, when the *Spring* of the *Aerial Particles* included in the Vessel, being in Part drove out, and therefore weakened by the *Rarifying Heat* of the *Fire* or *Sun*, were rendered unable to resist that of the *External Air*.

2dly, 'Tis evident, that 'twas the *Pressure* of the *Air* inflated into the Vessel, that first gave Motion to the *Water* thro' the Tube: from whence it may be reasonably argued, that 'twas the *Augmentation* of that *Pressure* by the *Heat* of the

the *Sun*, or Fire that did the same, or encreased the Rapidity of that Motion.

3dly, It may be probably asserted that, that which is here done does not proceed from the *Attraction* of the Body of the *Sun*, that draws the Water to it, in this *Experiment*, as to a Centre, but from the Activity of its Particles; otherwise the Fire could not have the same Force. For I presume no Man will assert, that Fire draws any thing to it as to a Centre; but that its Operation depends purely upon the Activity of its Particles.

4thly, I presume Mr *Newton* will not grant that the *Sun*, has such an *Attractive Force*, as a Centre, as to make the Water Ascend in a Stream to *f*, contrary to its *Natural Tendency* to the Centre of the *Earth*; or that the *Sun* has a Greater Power to make it Ascend to it as a Centre, than the *Earth* has to make it Descend to it, as a Centre: Or if it has, why does it not Continue to Raise it higher, when it comes to *f*, it being then nearer to it, than when it was in the bottom of the Vessel, and farther from the Centre of the *Earth*: And therefore according to him, the *Sun* should have more Power, and the *Earth* less; But yet we see that it Descends, which could not be if it had Power to raise it before. For if it had Power to raise it when there was a greater Resistance, it must necessarily continue it when there was a less; and therefore the Cause of its Ascent must be from the Pressure of the Rarified *Air* in the Vessel: Which shews that the *Sun* has Power, and does so Rarify the *Air*, as to make it Press harder upon the *Earth* or *Seas*; (contrary to Mr. *Newton*,) which proves our *Hypothesis*.

And this makes me apt to suspect that His Whole *Hypothesis*, is built upon a false Foundation; which is This, *That the Gravity of Bodies is lessened, as the Distance from their Centre is increased*: As appears Page 446, where He says, 'Now this force of Descent of Bodies towards the Centre, is not in all Places alike, but is still less and less, as the Distance, from Centre encreases: And in this Book (says Mr. *Halley*,) it is demonstrated that this Force decreases as the Square of the Distance increases; that is, the Weight of Bodies and the Force of their Fall, is less, in Parts more removed from the Centre, in proportion of the Squares of their Distance. So as for Example, a Tun Weight on the Surface of the Earth, if it were raised to the Height of 4000 Miles, which I suppose the Semediameter of the *Earth*, would Weigh but *One Fourth* of a Tun, or 500 Weight: If to 12000 Miles, or Three Semidiameters from the Surface, that is Four from the Centre, it would Weigh but $\frac{1}{16}$ Part of the Weight on the Surface, or a 100 and a Quarter: So that it would be as easie for the Strength of a Man at that Height to carry a Tun Weight, as here on the Surface a 100 $\frac{1}{4}$. And in the same Proportion does the Velocities of the fall of Bodies decrease. For whereas on the Surface of the Earth, all things fall 16 Foot in a Second, at One Semediameter above, this Fall is but Four Foot, and at Three Semidiameters, or Four from the Centre, it is but $\frac{1}{4}$ of the Fall at the Surface, or about One Foot in a Second: And at greater Distances, both Weight and Fall become very small, but yet at all given Distances is still something, tho'

the

the Effect become insensible. At the Distance of the *Moon*, (which I will suppose 60 Semidiameters of the *Earth*) 3600 Pounds weight but One Pound, and the Fall of Bodies is but $\frac{1}{3600}$ of a Foot in a Second, or Sixteen Foot in a Minute; that is, a Body so far off, descending in a Minute, no more then the same at the Surface of the *Earth* would do in a Second of Time.

This to me seems Precarious, and is Directly Contradictory to that *Experiment* of Mr. *Dehams*, giving an Account of the Height of the *Mercury* in the *Barometer*, at the Top and Bottom of the *Monument*, in *Philos. Transact.* N^o. 236. p. 2. Where He says thus; 'Some time since, I had Occasion to satisfy my Curiosity, concerning the Variation of the *Mercury* in different Heights; and accordingly in September 1696. I observed it on the *Monument*, by Two of Mr. *Quares* best Portable *Barometers*, by the best of the Two, for both differed,) I found the *Mercury* descended $\frac{1}{2}$ of an Inch, at the Height of 80 Feet, and $\frac{2}{3}$ at the Height of 160 Feet. But since that finding my Observations a little different from Mr. *Halley's* on *Snowden Hill*, in *Philos. Transact.* N^o. 229. I thought it necessary to renew my Experiments more nicely, and accordingly last November, tryed again with other Portable *Barometers*, which erred intolerably: So that, by the by, few of the Portable *Barometers*, that I have yet met with, are to be depended upon, in such Experiments. I therefore contrived to carry up the *Torricellian Experiment* to the Top of the *Monument*; Thus I provided a pretty large Glass Tube, this I lodged in Wire, and filled with well strained *Mercury*, which being cleared of all Air, I then plunged the Bottom

of the Tube into a broad Cistern of *Mercury*, and fixt both the Tube and Cistern together, in the Wire Case, or Frame; on the Top I left an Eye in the Wire, to suspend the Whole *Barometer* on a String, that it might hang Pendulously: Which is absolutely necessary, because if the Cistern be deeper on one side than the other, or if the Tube hang more towards one side than the other, it will cause a Great, and Erroneous Variation in the *Mercury* above, according as the Tube stands Perpendicular or not. My Instrument being thus; (I think very nicely prepared) I marked exactly the Height of the *Quicksilver*, upon two Labels of Paper pasted on each side the Tube, both at the Bottom, and in my Ascent up the *Monument*, the differences of the *Mercury's* Height, I measured with a *Gunter's* Chain, because a String would stretch. By the nicest Observation I could make, I found that at the Height of 82 Feet the *Mercury* fell $\frac{1}{10}$ of an Inch, and at about 164, $\frac{2}{5}$. By tarrying above something long, I perceived the *Pressure* of the *Air* was something altered: So that the *Mercury* in my Descent was about 01 of an Inch different, from my Observations in Ascending. Upon which, I repeated my Experiment, by Ascending and Descending quicker; at both which times, my Observations agreed exactly with the first Trial: From whence I conclude, that at every 82 Feet Height, or thereabouts, the *Mercury* will Descend One Tenth of an Inch. I was desirous to have Observed at this time, the Proportions of the Descent of the *Mercury*, according to Dr. *Wallis's* Remarks in his Letter to you, N^o. 231. but found it in vain, in so small an Height; however considering there is a difference

ference of Eight Feet between Mr. Halley's Observations and mine, which would alter the Mercury, or of an Inch, which is Perceptible; I am inclined to think that an Higher Ascent than 82 Foot is necessary to Cause the Mercury to Descend $\frac{1}{2}$, the Higher we are in the Atmosphere: but this I leave to your, and such other better Judgments and Observations.

By this Experiment, 'tis evident as Mr. Derham ascended, the Mercury in the Tube descended; and 'tis as evident, that the shorter the Pillar of any Fluid is, that is Buoy'd up in a Tube by the Pressure of the Atmosphere, the Heavier the Fluid is, that is so Buoyed up. For as Mercury is Heavier than Water, &c. so a shorter Pillar of Mercury is Equiponderate to the Pressure of the Atmosphere, and therefore the Mercury descending $\frac{1}{2}$ of an Inch in the Barometer, at the Height of 82 Feet, and $\frac{1}{2}$ at the Height of 164 Feet, the Mercurial Pillar being thereby so much shortened, plainly shews that it Increases in Weight, as it Ascends higher; and he seems to intimate, that according to Dr. Wallis Remarks, the Mercury should sink more $\frac{1}{2}$ part of an Inch for every 82 Feet 'tis higher in the Atmosphere. From whence it may be inferred, that the Gravity of Bodies, rather Encreases, as the Squares of their Distance, from the Centre of the Earth Increase: and this seems to me to be a very reasonable Consequence. First, Because the Resisting Pillar of the Air, is so much shortened, and therefore its Gravity lessened, part of it being taken off.

2dly, Because its Spring is weakned, having there room to Expand it self farther in such Proportion, as the Excess of a Circle, whose Diameter is 320 Feet longer than the Diameter of the Earth, is to the Circumference of the Earth.

And

and it has bin already shewn that the strength of the *Spring of the Air* like that of a *Watch*, is Encreased as 'tis Wound up closer; and therefore, if the same Number of *Aerial Particles*, be condensed in lesser space, the strength of their *Spring* will be Greater; and consequently they will have Greater *Pressure* upon the Surface of any Body they are contiguous to.

3dly, Because that Part of the *Atmosphere*, that is nearer the *Earth*, is Heavier, the *Aerial Particles* being there more Dense, and the *Atmosphere* more Impregnated with *Terrene Particles* that arise therefrom, and if so, the Velocity of the *Descent of Bodies* will Encrease, as they fall from a Higher Place: for as a Body is more Dense, and Ponderous, (that is, as it contains More Matter in Less Space, and requires Greater Resistance to sustain it;) so it makes a Greater Impulse upon the *Aerial Fluid*, which is Lighter, as it contains Less Matter in More space, and is more Rare or Light, as 'tis Higher or Farther from the Centre, and more Expanded; and consequently as the Ponderous Body is Higher in the *Atmosphere*, the *Aerial Particles* being there lighter, will be easier moved by it; and therefore meeting there with Less Resistance, they will there Descend Faster: Which is proved by Dr. Wallis's Remarks above mentioned; all which is directly Contrary to Mr. Newton. But by this Experiment, and several others of Mr. Boyles is very consonant to Nature, particularly his 19th Experiment, Concerning the *Spring of the Air*: And is confirmed by all Bodies Weighing less in Dense than in Rare Mediums, less in *Water* than in *Air*; and consequently if the Aerial Matter be Lighter, as 'tis Higher, a Grave Body must there proportionably Weigh more, as 'tis farther

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from

from the Centre: for things Weigh, or Descend by the same Degree of *Gravity*, that they surmount the *Medium* thro' which they Descend, if they Descend thro' a *Medium*, for in *Vacuo* they are equal.

One of the Undoubted Arguments that are brought to prove that there is a *Gravitation* towards the *Sun*, *Moon*, and all the *Planets*, I understand is taken from the Observation, that those Fowls, that take long Flights, generally Fly very high: Because, that the *Gravitation* of their Bodies towards the *Earth*, is lessened by their greater Distance from the Centre, and Consequently their Labour eased.

But the weakness of this Argument will appear, when Examined upon Mr. *Newton's* Principles; which are thus, *This Force of the Descent of Bodies, is not in all Places alike, but is still Less and Less; and Decreases as the Square of the Distance from the Centre Encreases; So that a Tun Weight on the Surface of the Earth, raised to the Height of 4000 Miles will Weigh but one Quarter of a Tun, or 500 Weight.*

Now supposing with Mr. *Newton*, that any Body at the Height of 4000 Miles from the Surface of the *Earth*, decreases $\frac{1}{4}$ of its Whole Weight: Let us enquire how much the Bodies of Fowl will Decrease in Weight, at the Height they fly; and that we may the better guess how much it contributes to their Advantage.

Let us take a *Wild Duck*, for Example: which is a Fowl that takes as long Flights, and Flies as high as most Fowl we have in *England*: and suppose it to Weigh Four Pounds, and to Fly 100 Yards high; then if this Duck loses Three Pounds at the Height of 4000 Miles from the Earth, the Decrease of the Weight of the Duck's Body at

the Height of a 100 Yards, will be to Three Pounds, as 100 Yards is to 4000 Miles. And because 100 Yards is contained in 4000 Miles 68000 times, (supposing but 1700 Yards to be a Mile) the Decrease will be as one to 68000. Now in Three Pound *Averdupois* (the largest Pound with us) there is but 23049 Grains, which Number is contained almost three Times in 68000, and consequently the Gravity of the Ducks Body at the Height of 100 Yards, will decrease in Weight, little more than the Third Part of a Grain: which will bear but a very small Proportion to the Difference, that we may suppose there is in the Weight of their daily Food, and will scarce Counterballance the Weight of the Least Feather.

This is supposing the Decrease of Gravity to be equal in every Part of the 4000 Miles from First to Last. But if the Gravity Decreases, as the Squares of their Distance Encreases; so as at a double Distance to have but $\frac{1}{4}$ of the Force; the Decrease of Gravity in the first 100 Yards from the Earth, will be next to Nothing; or altogether Inconsiderable.

But that the Duck, and many other Fowls; may Fly easier at that Height is very conceivable; tho' for a very different Cause. For 'tis observed, that the Lungs of some Birds have certain Apertures for the Air to pass out of each Lobe, into the Belly. Of which Mr. Ray in his Tract, *of the Wisdom of God in the Creation*, p. 166. says thus, 'Those large Bladders, or Membranes extending to the Bottoms of the Bellies of Birds, into which the Breath is received; conduce much to the Alleviating of the Body, and Facilitating the Flight: for the Air received into these Bladders, is by the Heat of the Body ex-

'tended into twice or thrice the Dimensions of the
 ' External, and so must needs add a Lightness to
 ' the Body. And the Bird when she would De-
 ' scend, may either compress this *Air* by the
 ' Muscles of the *Abdomen*, or Expire as much of
 ' it, as may enable her to Descend Swifter, or
 ' Slower as she pleases.

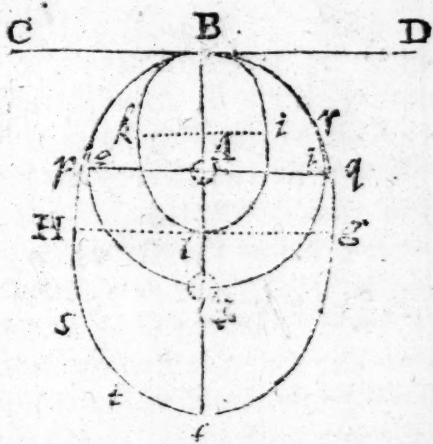
This *Air* may not Only conduce to the *Allevi-*
ating the Body and Facilitating of their Flight, as
 'tis Rarified by the Heat of the Bodies. But, *2dly*,
 Because the *Pressure of the Atmosphere* at that
 Height, is sensibly lessened, (as appears by Mr. Der-
 ham's Experiment of the Subsiding of the *Mercury*,
 as he ascended the *Monument*,) by which the *Spring*
 of this included *Air*, may not only be farther Ex-
 panded, but will there find more Space; the
 whole Body being thereby Swell'd, or Extended,
 so as to take up more Room (as Mr. *Boyl* has
 Experimentally proved, upon the Bodies of Birds,
 and other Living Creatures in the *Air Pump*;
 and consequently eased. *3dly*, As the taking off
 the *Pressure of the Atmosphere* makes the Body
 Bigger, so its Pores will be more Open, and Perspi-
 ration more free, (as we see by *Cupping-Glasses*;
 which will keep the Fowl Cooler, and Easier du-
 ring its Flight; which seems to be a more Just
 Cause of their Flying at such a Height.

In Mr. *Harris's Lexicon Tech.* under the Word
Planet, from Mr. *Newton's Principles* I find these
 Words.

' From the uniform Projectile Motion of Bo-
 ' dies in straight Lines, and the universal Power of
 ' *Attraction* or *Gravitation*, the *Curvilinear Mo-*
 ' tion of all the Heavenly Bodies do arise.

' Thus if the *Celerity* of *B*, be exactly corre-
 ' spondent, to the *Attractive Force* of the Centra-
 ' Body *A*, neither will prevail; and the Bod-

preserving an equal Distance from the Centre will describe the Circle $B e E b$. If the Celerity be greater, it will overcome the *Attraction*, and cast it self farther off the Centre for some time, and so Revolve about it in the larger *Elleipsis*, $B H f g$; the Central Body possessing that



Focus A, which is nearest the Point *B*, where the *Attraction* began. But if the Celerity be smaller, the *Attraction* of the Central Body *A*, will be too hard for it, will Force it for some time to come nearer, and to describe the lesser *Elleipsis* $B k l i$: the Central Body possessing that *Focus A*, which is farthest from the Point *B*, where the *Attraction* began: As will be very plain from the Consideration of the Figure relating hereto.

To which I answer, it must be granted (as above,) that when the Projectile Motion of the Planets, is in its Direction, Perpendicular to a Line from the *Sun*, and in its Degree of Velocity so nicely Adapted, and Contempered to the quantity of the *Sun's* *Attraction* there, that neither can overcome the other; (the *Force of Gravitation*

vitation towards the *Sun*, and the Celerity of the *Planets* proper Motions being perfectly in *Equilibrio*) the Orbits of such Revolving *Planets* will be compleat Circles. And if the Celerity be Greater, it will overcome the *Attraction*, and cast it self farther off the Centre. But that it should then Form an *Elliptic Line*, and continually Revolve about it, as in the larger *Ellipsis B H f g*, I can by no means admit.

For suppose the Body *B*, to be *Jupiter* or *Mars*, and its Projectile Motion to be in a Right Line from *C* to *D*; but by the *Attractive Power* of the *Sun* at *A*, is turn'd towards *r*: but there the Projective Force being too strong for the *Attractive Power*, it breaks out, and tends more towards the *Line of Direction C D*, and proceeds in *g*, and *g* to *f*; but at *f*, the Projectile Force being the same, and the *Attractive* but $\frac{1}{4}$ of what it was at *B*, if the whole Force could not hold it when it was at *r*, it cannot be supposed that $\frac{1}{4}$ of it should *Attract* it back when it is at a double Distance, *viz.* from *f* to *S*; the same Power being required to *Attract* it from *f*, to *S*, as there was to *Attract* it from *B*, to *r*, the *Curves*, or *Deflection* from the Right Line, being Equal, or that from *f*, the greater, and because the Line is *Curv'd* in Proportion to the *Sun's* *Attractive Power* at *A*, it will follow, that as this Power gradually lessens as the Body *B*, is at a greater Distance so the *Conatus recedendi a centro motus*, or the Body *B's* endeavour to reassume its First Direction will carry it out farther from *S*, in a *Spiral Motion* towards *r*, which *Spiral Line* will still Recede farther from the *Sun* at *A*, as the *Attractive Power* at *A* lessens, till it gets out of the *Sphere* of the *Sun's* *Attraction*, where 'twill return into a *Right Line*, according to its First Direction

Projection. So that from this *Cause*, 'tis impossible that any *Planet*, or the Body *B* should proceed in an *Elliptic Line* from *f*, to *S*, *H*, and *p*, except the Projective Force lessens, or there be another *Sun* to place in the other *Focus* of the *Ellipsis* at *E*: and till then all the *Phænomena* of the *Cælestial Motions*, that Mr. *Newton* has deduced from this *Cause*, in an *Ellipsis*, will be Precarious.

C H A P. XXIII.

AS the *Ætherial Particles* darted from the Body of the *Sun*, have Power to *Rarify*, and *Dilate* the *Atmosphere*, and cau^d it to *Press* harder upon the *Earth*, and all other Bodies 'tis contiguous to; so 'twill fairly, and naturally Account for all the *Phænomena* of the *Barometer*: and of all *Constant*, and *Anniversary Winds*, if not of all *Winds*; the chief of the First are these Two.

First, That the *Mercury* in the *Barometer* Rises higher in the Tube in clear Dry Weather; 2^{dly}, That it falls in Thick Cloudy Rainy Weather, tho' a *Cubic Foot* of *Air*, is Lighter in Dry, Serene Weather, than 'tis in Thick Cloudy Wet Weather; and these must be necessary Effects of this Cause. For if the *Ætherial Particles* have Power (as has bin proved) to *Dilate* that part of the *Atmosphere*, that is contiguous to the Surface of the *Earth*, and All things thereon; so as to make it take up more Room, and *Press* harder upon it, the more that part of the *Atmosphere*

Sphere is exposed to, and abounds with *Ætherial Particles*, the more Room 'twill require; and consequently, 'twill Press harder upon the Surface of the *Earth*, and likewise upon the *Mercury* in the Cistern of the *Barometer*; which will accordingly Force it to Ascend Higher in the Tube proportionally: as is constantly observed in Fair Weather. For when the *Air* is most Serene and Clear, the *Ætherial Particles* have a free Passage, there being then nothing to intercept them and the *Earth*; wherefore the *Air* must then be most Rarified, and Dilated by them, and therefore Cause the abovementioned Effects, i. e. the *Atmosphere* to Press stronger upon the *Earth*, &c.

But if the *Solar Particles* are Intercepted by a *Cloud*, the *Air* betwixt the *Earth*, and that *Cloud* will not only be less Rarified, but Condensed in their Absence; which will make it take up less Room (as it does in the Ball of a *Water Weather-Glass*,) and consequently bear less upon the *Quicksilver* in the Cistern (as the *Air* in the Ball does upon the *Water* in that *Weather-Glass* in Wet Cloudy Weather,) and therefore the *Mercury* in the Tube must descend Lower, as the *Water* in the other *Glass* will Ascend Higher. And because the *Air* is Condensed when the *Ætherial Particles* are intercepted by a *Cloud*, a Cubicroot of *Air* will be Heavier in Moist Cloudy Weather, than when 'tis Rarified in Clear Serene Weather, as has bin proved, by an Exhausted *Æolipile's*; Weighing several Grains more, upon the immision of the *Air* again into it in Rainy Weather than in settled Fair. So that a Pillar of *Air*, that makes the *Mercury* to Rise in the *Barometer*, in Fair Weather, is really Lighter, if we may Judge of the Whole by a Part (tho' generally esteemed otherwise) than it is in Wet

Wear

Weather, when the *Mercury* falls, Which evidently shews that the Pressure of the *Air* upon the *Mercury* in the Cistern, and consequently its Rising in the Tube, is not so much owing to the Gravity of the *Air*, as to its Spring. Which confirms our *Hypothesis*.

But it may be objected, that contrary to this, the *Mercury* frequently Rises in the Tube in Misty Weather, when the *Air* is Thick, and Cloudy; and the *Solar Particles* are thereby intercepted from the *Earth*. 2dly, That in Windy Weather, it frequently Falls, tho' it be Fair and Clear.

As to the first, 'tis evident by Mr. Derham's Observation of the Weather in the Years 1699, and 1700, inserted in the *Philos. Transact. Num.* 245, and 262, That the *Mercury* never Rises in the Tube of the *Barometer*, in Misty Weather; but when the *Air* is very much Rarified, and the *Mercurial Cylinder* Rises up to Fair, or Thirty Inches high. Or if at any time, the *Mercury* Rises in Misty Weather, under that Station, 'tis when there is such a Propensity in the *Air* to Fair Weather, that it never stops till it Rises to that Degree, (as may there be observed) and if the *Mercury* does not stand above *Changeable*, or 29½ Inches, it always Falls in Misty Weather, except Rain immediately precede it; and then its Rising proceeds only from a Restitution to Fair Weather. And this will appear to any One who will be at the Pains to examin it thro' those Years: and because I find this Rule exact throughout these Years, I shall conclude it holds in all other.

And the reason I conclude to be, is this, that when the *Air* is so much Rarified by the Presence of *Etherial Particles*, as to buoy up the *Mercury*

ry in the *Barometer* to Thirty Inches, if then any Light Cloud, or Vapour intercept the *Solar Particles*, and the *Earth*, so as to Cause the *Air* betwixt the *Earth* and that Cloud to be Condensed, and take up less room, by which the Resistance of the *Air*, below the Cloud will be weakned, and therefore the *Spring* of the Superior *Air*, or *Ætherial* Particles above the Cloud, will have a greater Power to Force thro' it, and Cause it to descend with them in that Mistling Rain: and because they may be hindred by the same Cloud, from returning back again: they may not only Crowd and Rarify the Inferior *Air*, where they are pent betwixt the Cloud and the *Earth*, so much as to make the *Quicksilver* Rise; but may be crowded to that Degree as to Raise it much Higher, than at any other time, even in Fair Weather, as on *December 22d 1700*. But if the *Mercury* stands at *Changeable*, the *Air* being then already so clogg'd with watry Particles, that the *Mercury* is equally inclin'd to Rise or Fall; then the Addition of more Humid Particles must Preponderate, and Cause so great a Resistance to the *Ætherial* Particles above the Cloud, as totally to exclude their Descent, by hindering their Passage; or making it so thick, that the *Ætherial* Particles are not able to force a Passage thro' it: and at the same time, by obstructing them, Cause a greater Condensation of the *Air* below the Cloud, and therefore cause the *Mercury* at that time to subside.

That the *Ætherial Particles*, when the *Barometer* is High, may force thro' a Cloud in Mistling Weather, and being pent up betwixt the Cloud and the *Earth*, may have Power to Crowd and Rarify the *Atmosphere*, to that Degree as to make the *Mercury* in the *Barometer* Ascend higher, than at another time, when they are unconfined,
and

and at liberty to disperse themselves any way, as in Fair Weather, seems confirm'd by this ; That the *Barometer* generally Rises in the time of Rain, tho' it descended till the Rain began ; which I conceive happens, for the same Reason, *viz.* because the *Ætherial* Particles break thro' the Cloud, and descend along the Rain.

If it should so happen in Misty Weather, that when the inferior *Air* is much crowded with those Descending *Ætherial* Particles, that there should be a sudden supply of Watry Particles added to the Cloud, which might so much encrease its Weight, as to make it Descend, not in Rain, but whole towards the Earth ; it would not only Raise the *Mercury*, but by compressing the Aerial, and *Ætherial* Particles betwixt it and the Earth, (like *Air* in a pair of Bellows) might Cause them to gush out on one side or other, in a violent Torrent, where they find least Resistance, and cause that *Phænomenon* we call *Wind*, which by driving the *Ætherial* Particles in other parts of the *Atmosphere*, in a violent Torrent before it, and thereby raising, or bearing them up from the Earth, will hinder the Pressure of their Spring thereupon ; and consequently Cause the *Mercury* to Descend in the *Barometer*, in Windy Weather.

That *Wind* is nothing else, but *Air* Compressed, and Forced thus with violence thro' a Narrow passage, is plain in a Pair of Bellows ; where the *Air* entering by a Valve on the under side, when the Bellows are Dilated, becomes *Wind*, when forced out at the Pipe, by the Pressure of the sides in contraction, or what is Equivalent to *Air*, *viz.* *Water* Rarified as in the *Æolipile*, where the *Water* is Rarified, and by the Resistance of its Metallic Sides, is forced thro' a narrow

row Passage, and becomes *Wind*: which otherwise, if the Top had bin open with a free Passage into the *Air*, as in a Pot, or Kettle, would have bin Vapour. So the *Air* that we Respire, if we Breath it out with an open Mouth is Vapour, but if we Blow it thro' a Narrow Passage its *Wind*.

Wind may be Caused by Simple Pressure, as in a Pair of Bellows; or upon one side only, or more, as by a Fan, or the Wings of a Fowl flying; or by the Clashing of several Clouds, or by the Sudden descent of a Cloud &c. A Famous Instance of the last we have in those Dreadful Storms on the Coasts of *Guinea*, which the Seamen call the *Ox Eye*, from their Beginning; because at first it seems no bigger than an *Ox's Eye*: But descends with that Celerity, that in a very little Space, (many times before they can prepare them selves for it;) it seems to them to overspread the whole Hemisphere, and forces the *Air* from under it, with so much Violence, that their Vessels are sometimes scattered several ways, sometimes contrary, and sometimes Sunk down right.

It seems so little at first, by reason of its great Distance; for the *Sun* being there Vertical, its Rays are much stronger, wherefore it raises more Vapours, and carries them much higher, before they condense into a Cloud: Which Vapours seem to be particularly collected in these Parts, by reason of the interruption of the *Trade-Winds*, by those Vast Mountains in *Guinea*, or *Negroland*; which Wind being diverted from its wonted Course, leaves those Seas often becalmed, and the Air Stagnant, or put into a Gyration, as we see often the Waters in Rivers, betwixt Two Streams run back again in a Circle, as betwixt the Arch-

es of a Bridge, &c. and what is brought along with the Stream, is frequently lodged in those Places : So the *Trade Wind*, separated by those vast Mountains, may make Two Streams, which may turn back again, where they meet, and cause a Gyration of the *Atmosphere* in that Part, by which the Vapours Condensed in other Parts, will be easily thrown off upon this, in great Quantities : which by this Circulation may be buyed up, till growing too heavy to be supported, they stop the Circulation, and descend with such Violence, as to Cause the above mentioned Effects.

2dly, *Wind* may proceed from *Rarification*, and *Compression* ; an Eminent Example of which, are those Constant Winds from *East* to *West*, throwout the Year in the *Torrid Zone* : Which must necessarily proceed from the *Rarification* of the *Atmosphere* in those Parts, and the Waters in those Seas. For the *Air* and *Waters* in those Parts being Rarified, must take up more Room ; and taking up more Room, must suffer a Compression, as in an *Æoliopile*, and force their Passage some way or other : But by reason of the Density, and Contrariety of Particles towards the Poles, it cannot be towards them ; and by reason of their *Gravity*, that is, they being more Grave than the *Ætherial* Particles, they cannot ascend Perpendicular, and consequently it must be either *East*, or *West* : But they cannot go back towards the *East*. *First*, Because of the Pressure of the Body of the *Sun*, meeting them, and impelling 'em, the other way. 2dly, By reason of the Activity of the *Solar* Particles, which have there a greater Force to Act upon, and Rarifie the *Air* under them.

3dly,

3dly, By reason that the Circular Motion of the Whole *Aerial*, and *Ætherial* Fluid inclines them to the contrary; and therefore those Rarified *Aerial Particles*, and Vapours raised by the Heat of the *Sun*, must move before it *Westward*: and cause that *Trade Wind*, which always blows from *East* to *West*, in the *Torrid Zone*, with some little Variation on each side the *Equator*, as the *Sun* moves from One *Tropick* to other.

And as the *Sun* Causes this *Constant Wind*, from *East* to *West* in the *Torrid Zone*, so as it approaches the *Tropics*, by Liquifying the Snow and Ice, towards the *Poles*, and Rarifying the Air in those Parts: it may be the Cause of all *Anniversary* and *Periodical Winds*; which as they are reverberated from the Shores, Hills, and Mountains, Islands and Continents, and varied by the Pressure of the *Planets*, (particularly of the *Moon*, as it passes the several *Nodes* of the *Ecliptic*, and makes different Positions, or *Aspects* with the *Sun*,) may be the Cause of all *Winds* whatsoever, either Immediately or Mediatly, by the clashing of Clouds raised by the *Sun*, and thrown off by those *Winds*, to several parts of the *Atmosphere*. Allwhich, may therefore probably be regular, as *Gust. Parker* in his Monthly Papers seems to make out; except such as are generated in the Bowels of the *Earth*, which are Rare, and only in *Earthquakes* break out in one Gush, except they may proceed from Air and Water Rarified in such Burning Mountains as *Etna*. And from what Cause soever they proceed, they have this constant Effect, to make the *Mercury* in the *Barometer* descend: But the *Barometer* does not predict *Winds*, but is affected with it, only when it comes, and so long as it continues, and no longer. Which shews that
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this Effect proceeds from the abovementioned Cause, and confirms our *Hypothesis*.

But it may be objected, that in the *Torrid Zone*, the Air is more rarified and crowded with *Ætherial Particles*, than with us, and consequently that the *Barometer*, should stand higher there constantly, than with us at any time. But on the contrary, 'tis never so high there as 'tis with us generally, *viz.* at *Changeable*, For Sir William Beeston Governour of *Jamaica* tells us in his *Philos. Transact.* N^o 220. p. 225. that he set up a *Barometer*, with all the exactness he could, and when it was first in the Cistern, the *Mercury* stood one Degree below *Changeable*; I diligently observed it every Day (says he,) and found that in the Mornings, before the *Sun* arose it would 'be there, and as the Heat encreased with the Day, it sunk to within one Degree above *Rain*, there it continued several Days, and never altered above three Degrees tho' sometimes *Fair*, sometimes *Rain*, and sometimes *Cloudy*, and one Morning leaving open my Window, and the *Sun* having *South Declination*, it shone on the visible part of the Tube, and in Half an Hour it sunk three Degrees, (which I never observed it to do with Heat in *England*.) I presently shut the Window, and in one Hour, it arose again to within one Degree of *Changeable*: After it had kept this Course, in several Weathers for six Weeks together, I began to doubt whether it were well adjusted, and therefore took it down, new filled the Tube, turned it three or four Times up and down, to let out the Air, and put it up with great care, it continues the same, never by one Degree to *Changeable*, nor down by one Degree to *Rain*, so that the whole progress of the *Mercury* is but $\frac{1}{2}$ of an Inch.

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This *Phanomenon* (supposing the *Barometer* to be well adjusted,) I conceive proceeds from these two Causes. *First*, Because as the Sun appears above the *Horizon*, the Wind arises and encreases, as the Sun approaches, till it becomes *Vertical*, at which Time it blows freshest, and consequently for the abovementioned Reasons, should cause the *Mercury* to descend lowest. *2dly*. I conceive that the Sun has so much force there, as to drive the Cruder Aerial Particles, (which have the greatest Force upon the Surface of the *Mercury* towards the *Poles* : So that the Air there, consists of much finer Particles than with us ; so fine that some of them are capable of passing thro' the Pores of the *Mercury*, into the Tube of the *Barometer*, which being there dilated by the Heat of the Sun, will cause the *Mercury* to sink, as in our Tubes that are not well Fixt, or as in a *Water-Weather-Glass*. And that there are Particles even in our Air, much more in that, that are capable of Pervading the Pores of *Mercury*, and expanding themselves in the Tube is manifest : For in the *Torricellian Experiment*, when the Air was well Exhausted, and the *Mercury* sunk quite out of the Tube into the Cistern. I have seen the Air Bubble thro' the *Mercury*, into the Tube, which must be very fine Air not Exhausted out of the External Vessel, passing thro' the Pores of the *Mercury* into the Tube, where the Air must be supposed to be more evacuated, by the descent of the *Mercury*, than it could out of the External Vessel, purely by the Expansion of its Springy Particle. By which that *Phanomenon* is Caused, and not by *Suction*, as Mr. *Boyl* has evidently Demonstrated, or otherwise it must be contained in the Pores of the *Mercury*, which Expands it self into the Tube,

Tube,

Tube, the Pressure of the *Atmosphere* being there taken off, and if either way, there must be Particles in the Air capable of Entering into the Pores of *Mercury*, and Expanding themselves when the Pressure of the *Atmosphere* is taken off; and consequently may Cause the above mentioned Effects, by getting into the Tube in the *Torrid Zone*: for when the External Air is Hot, it Rarifies the Air thus got into the head of the Tube, which Presses upon the *Mercury* in the Tube, and causes it to Descend against the Pressure of the External Air on the *Mercury* in the Cistern: but when the External Air is Cold, it condenses this Air got into the Tube which takes off the Pressure on that part, and fills the External Air with more gross Particles; by which its Pressure upon the *Mercury* in the Cistern is rather Encreased, than Diminished, which Causes the *Mercury* in the *Barometer* there, to move so little either Higher or Lower.

2dly, It may be Objected, that tho' the *Mercury* seldom or never fails to Sink in the *Barometer*, when a Southern Wind Blows; yet 'tis observed to Rise often when the Wind Blows North: which comes to pass not only because a Southern Wind, by driving the Aerial Particles before it, hinders their Spring from pressing upon the Surface of the *Mercury*; but because, it blowing from the *Equator*, towards us, brings along with it, these Vapours that are raised by the Sun in those Southern Seas, which being Condensed in our Climate, clouds the Air, and hinders the Descent of *Aethereal Particles*: upon which, not only a Descent of the *Mercury*, but Rain generally follows. But on the contrary, a North Wind blowing from a Region where there are few Vapours Raised, sometimes clears the Air, by driving

ving away those Vapours already gathered therein : by which the Descent of the *Ætherial Particles* before were hindered, and by this making way for them, it adds more to the Pressure of the Air, than it takes away.

'Tis observed, that Rain more certainly follows the Descent of the *Barometer*, when the *Moon* is in the Full, or Change, than at other times : which shews that it, (and the other *Planets*) has its Effects upon the Air. Which is eminently confirmed by those Hurricanes in *Barbados*, and the *Leewards Islands* ; of which, and their Prognosticks, or Forerunning Signs, Captain Langford gives a very fair account, from his own Observations, and Experience, in *Philos. Transact.* N. 246. pag. 407.

Where he says, it has bin the custom of our *English* and *French* Inhabitants of the *Caribbee Islands*, to send in about the Month of *June*, to the Native *Caribbees* of *Dominico*, and *St Vincent*, to know whether there would be any *Hurricanes* that Year ; and about 10 or 12 Days before the *Hurricane* came, they did constantly send them word ; and it very rarely, or seldom failed, that ever I had Experience of : but the Inhabitants have pretended, that sometimes they did fail in their *Prognosticks* ; which *Prognosticks* he afterwards learned from an Inhabitant of *Dominico*, and are these,

First, He says, all *Hurricanes* come either on the day of the Full, Change, or Quarters of the *Moon*. *Secondly*, If he will come in the Full *Moon*, you being in the Change, then observe the Signs, That Day you will see the Skies very Turbulent ; the Sun more Red than at other times ; a great Calm ; and the Hills clear of Clouds, and Foggs over them ; which in the High

Highlands are seldom so; likewise in the Hollows or Concaves of the Earth and Wells, there will be a great Noise, as if you were in a great Storm; and at Night the Stars looking very big, with Burs about them, and the North West Sky very Black and Foul; the Sea smelling stronger than at other times, as usually it does in great Storms; and sometimes that Day, for an Hour or Two, the Wind blows very hard Westwardly, out of his usual Course.

On the Full of the *Moon*, you have the same Signs; but a great Burr about the *Moon*, and many times about the Sun: the like Signs must be taken notice of on the Quarter Days of the *Moon*, in the Month of *July*, *August*, and *September*; for the *Hurricanes* come in these Months; the soonest that ever I heard of, was the 25th of *July*, and the latest was the 2th of *September*; but the usual Month they come in is *August*.

As to the Causes of these *Hurricanes* (after he has remarked, that where the Sun comes to a *Zenith*, there is always Fair Weather; but at his return to the Southward, it occasions, generally much Rains and Storms, as *Tornado's*, &c.) He concludes the Cause of *Hurricanes* to be the Sun's leaving the *Zenith* of those Parts towards the South; and Secondly, The Reverse or Rebounding back of the Wind, which is occasioned by the calming of the Trade-wind.

That these are Causes is certain; For, First, the Sun is a Cause, or otherwise they would not always happen when it was in the same Point, descending from the Northern *Tropic* to the *Equator*, in the Month of *August*, or never known above eight Days (at least by him) before or after.

2dly, The Rebounding back of the *Trade-wind*, seems to be the immediate Cause; but I conceive this is not Caused by the Calming of the *Trade-wind*, but the calming of the *Trade-wind* is Caused by it; and the reverse of the *Trade-wind* is Caused by the Sun, when in that Point. For I conceive that the Sun, when it ascends from the *Equator* towards the *Tropic of Cancer*, as it tends then, every day more Northwards, so it makes an Impulse upon the Air, or drives it before it Northwards; which Causes a Wind to blow from the Southern side of the *Equator*, to the Northern: or to blow from betwixt the *East* and *South-east* to the *West*, and *North-west* Point, and it continues so to do, till it approaches the *Tropic of Cancer*, and by so doing, drives the Northern Vapours towards that Pole, and confines them beyond the *Tropics*; by which means the Air continues Fair and Clear, till it approaches that Zenith: but when it returns from thence the Sea tending then Southwards, makes an Impulse upon the Air that way, and drives it towards the Southern side of the *Equator*; and causes a Wind then to blow from the Northern side of the *Equator* to the Southern, by which those Vapours drove beyond the Northern *Tropic*. The Stream of the Air following this Wind, and therefore giving way to them, they press in along with it, and cause Clouds, Rain, and Storms in the *Torrid Zone*, as the Sun returns to the *Equator*, which when it comes to the Zenith of the *Carribee Islands*, blows fresh into the Gulf of *Mexico*; and at the same time the Sun powerfully Rarifies the Waters in those Seas, which Wind Rarified Waters being reverberated from the Rocks and Highlands, and circulating by the Banks, gather together in the Middle, in a

of Whirlwind ; by which the Superior Air is put into a Gyration, which will derive the Clouds from the adjacent Parts into it ; and being there collected, by their Pressure joyned with that of the *Moon's* Force, drive those Winds back again against the *Trade-wind* ; at first but with an equal Force, which Causes that Resistance to the *Trade-wind*, that makes the preceding Calm. At what time the Conjunctive of these several Causes, by putting the Air in those Parts into a Ferment, at first only Cause the above mentioned Prognosticks ; but against the next Full or Change, gathering more Forces, it rushes out with incredible Violence, and Causes those great Devastations, he there gives an Account of. By which 'tis plain, the *Moon*, as well as the *Sun*, has a great Operation upon the Weather ; these *Hurricanes*, generally, if not always, happening either in Full or Change : and as it has Power here, so proportionably in all other Parts of the Earth : which probably proceeds not only from the Pressure of the *Moon's* Body, but also from the Activity of its Luminous Particles, which if they have not Power to Exhale new Vapours ; yet they may continue those already raised by the Sun : which by putting the Air and Seas into a Ferment, may be a great Cause of the above mentioned Effects.

This *Hypothesis*, viz. That the Reverberating of the *Trade Wind* from the Rocks and Banks of the Land, is a Cause, in part, of the contrary Wind in *Hurricanes* : he seems to confirm, first in pag. 415. where he says, that from *Porto Rico* downwards, both that Island, as well as *Hispaniola*, and other Islands there adjacent, are of vast greatness and very High Lands, that of themselves does most commonly give Reversal or

Westerly Winds at Night throughout the Year. This height of the Land, in Conjunction with other Causes, does very much favour our *Hypothesis*; tho' it alone can scarce be supposed to do it; neither do I take it to be the only Cause of those Westerly Winds, he speaks of, at Night throughout the Year. The main Cause of them, I take to be the greater and quicker Condensation of the Air, that is contiguous to the Seas, than of that at Land; by which those Vapours, and that Air, that were Raised and Rarified there, by the Sun in the Day time, and impelled to the Land; return back again at Night. This Condensation, by Contracting the Air into less Room, making way for them, as we see Vapours from High Grounds, fly to Rivers and Lakes, and condense there in Fogs.

2dly, He says, pag. 414. It is usual in our Sailing from *Barbadoes*, or those Islands, to the North, for a Westerly Wind, when we begin to lose our Easterly Wind, to have it *Calm*, as it is before *Hurricanes*; and then the Wind springing up, Causes it to be Various: but after the Westerly Wind comes fresh, we have bin constantly without those Shiftings from Point to Point.

It seems, as there is a Constant *Trade-Wind* from *East* to *West* under the *Equator*, so where this ceaseth (from the Elasticity of the Air, which like a Spring bent one way, being let go, Reverts as far back the other,) there springs up a Contrary Wind, which blows Constantly from *West* to *East*: and betwixt these two, there is sometimes a *Calm*, and sometimes Shifting Winds from Point to Point; proceeding from the mutual Resistance of each other; as has bin assigned above, in the beginning of *Hurricanes*, which confirms the *Hypothesis*.

But

But it may be Objected, by those that hold the *Copernican System*, That 'tis not the *Rarification* of the Air, that Causes this Wind to blow constantly from *East* to *West*, in the *Torrid Zone*: but 'tis the Earth moving upon its own *Axis* from *West* to *East*, faster than the *Atmospherical Air* can follow it, which makes the Air only seem to Move towards the *West*, and the Earth seem to stand still. But then, this contradicts another Answer of theirs; when 'tis objected against them, that if the Earth moved, as they assert, a thing droped from the Top of a Steeple, or any High place, or an Arrow shot upright, would fall far from that Place to the *Westward*, that part of the *Earth*, that 'twas Perpendicular too, being Moved so far *Eastward* in the time of its descent. For if the Earth Moves faster to the *East*, than the *Atmospherical Air* can follow, that which descends thro' the *Atmospherical Air*, must stay behind, it being as near to the Centre in one part of the *Atmosphere* as another. In answer to this, they say, the *Earth* not only Moves, but the *Atmosphere* and all things therein, Moves also along with it; but if the Earth and *Atmosphere* Move together, it cannot from that Cause, make the Trade-Wind: for the *Atmosphere*, will then be all one in respect of the Earth, as if it were Stagnant; there being near the Earth no difference betwixt them. So that the one must necessarily be false, as the Answers or Reasons are contradictory.

But this last Answer of theirs, in our *Hypothesis* is conclusive, where the Pressure of the Whole *Atmospherical Hemisphere*, that is contiguous to the Earth on one part, and the Condensation, and Recession of it, on the other, carries the Earth along with it, as a Child is carried in the Womb,

every part of the *Earth* and *Atmosphere*, always having the same Relation and Situation to each other; the *Atmosphere* differing only, as 'tis Rarified by the Presence, or Condensed by the Absence of the *Sun*: And the *Trade Wind* being a Particular commotion of the *Atmosphere*, in that part only, that is near the *Earth*, can no more affect the Descent of *Grave Bodies*, than the Wind of an *Aolipile*, proportionably, or any other Wind, can affect any thing that falls within it.

C H A P. XXIV.

Fifthly, as the *Solar Particles*, have power to Rarifie, and Dilate, so they will Cause *Vegitation*, and *Odour*, &c.

For as the *Solar Particles*, by their Activity, do Heat and Rarifie the Air, and several Juices contained in the Pores and Tubes of *Vegitables*; so they Cause them to take up more Room, and therefore because they cannot then be contained, in the same place, they must Evaporate out of the ends of the *Sprigs* or *Branches*; because this being least and most exposed to the *Sun*, their Juices, and the Air contained in their Pores, will be rarified by the *Solar Particles*, and Forced to Evaporate before those in the *Trunk*, that lie deeper, will be at all Affected. And therefore, the tendency of the Rarified *Juices*, will be towards the *Sprigs*, they being hindered from passing towards the *Roots*, by those Juices in the *Body of the Tree*, that are yet unaffected by the *Sun*.

Part of the Air, and Juices in the *Vegitable Tubes* being evaporated, the Spring of the remaining *Air* will be weakned, and the Weight of the *Juices* in the *Vegitable Tubes*, will be lessened. The Spring of the *Air* in the *Tubes* being Weakned, and the Weight of the *Juices* lessened, the Pressure of the *Atmosphere* will force those similar *Juices*, that subside about the *Roots* into those *Tubes*; where the *Atmosphere* now finds least Resistance: and as the Action of the Solar Particles, causing the several *Juices* in the *Vegitable Tubes* to Evaporate is continued, so the *Juices* from the *Roots*, by the *Atmosphere* will be pressed forwards; and after divers Separations and Subtilizations by Percolation, and Digestion, will be assimilated into the Bodies of *Vegitables*; being a similar Juice prepared in its passage from the *Root* to the *Flower* by similar Pores. And if these *Juices* at the *Roots* abound, as in the Spring they do, (being horded up in great abundance, by the preceding Winter,) they will Germinate into *Leaves*, and *Branches*, by insinuating into the Pores, and sticking to the Extremities where they are hardned, into similar Bodies, by the Heat of the Sun: The same Cause having similar Effects, upon similar Particles.

But as that Stock at the *Root* decays or lessens, so for want of equal supplies, they will Germinate less; and as the Heat in *Summer* encreases, so the Cruder Part of their Seed, and *Fruit* will be Evaporated, and they thereby Subtilized and Matured. And in *Autumn*, when this Stock is spent, (or the *Juices* by reason of the then weak Action of the Sun, cannot ascend) the *Leaves*, for want of support, will decay, and the *Fruit* will fall.

That

That the *Sun* operates thus, upon this Matter, is evident to the Senses ; which is apparent in an *Apple*, which whilst its Green and Young, by reason of the abundance of the Crude Nitrous Salt, and Earth in that *Juice*, collected at the Roots of the Trees in the Spring, has an Unpleasant Astringent Taste, in which we manifestly perceive the Acid bitter of *Niter* and Stipticity of the *Earth* ; whose Particles being then not well Digested, but Gross, Cold, and Rough, for want of Fermentation, and Im-mastication, being thus Crude and dissolved in the *Saliva*, or *Oral Humidity*, when they enter with it, the Pores of the Tongue, by Grating against the *Papillary Prominences*, they *Irritate* their *Fibres* ; which Irritation being by them communicated to the *Nerves*, causes *Undulation* of the Spirits contained in them : Which are thence transmitted to the *Corpora Striata*, with which they are continuous ; which represent to the *Soul*, such *Impressions* as they Receive, which coming from that Organ, makes the Alteration in the *Sentient* which we call *Taste*, and the Perceptions, or Observation of that Alteration we call *Sensation*. But because those Particles are Crude Rough and Stiptick, when they enter the Pores of the *Papilla*, they draw their *Fibres* inwardly along with them, and so cause a Contraction of the *Tongue*, which make that particular Alteration in that *Sensorium*, which we call *Astringent*.

But as the Power of the Sun encreases, and *Autumn* approaches, so this Moisture at the Roots is more and more imbib'd by them, and exhaled by the Sun, which Causes the Crude Earthy Particles to be more fixt, and consequently not so easily separable : So that now only the

more Pure, Saline, and Spirituous Particles, that are easily miscible with Water subside; being excited by the *Peristaltick*, or growing Motion of the *Roots*, and Imbibed by them, and conveyed to all parts of *Trees*, &c. Which serves now, not so much to augment the *Fruit*, as to Digest and Meliorate it; for when it comes to half its Maturity, it becomes Sower, for then those Cruder, Terrene Particles are divided by these Finer; but have not bin Fermented or Agitated enough to make them Smooth, but only less and rather more Sharp: The Saline, and Acid particles, being more freed from the Terrene; which because they are less, they sink more deep into the Pores, and by their Roughness and Sharpness, Prick and Torment the *Sensorium* Deeply, which Causes that Perception which we call *Sowerness*.

But as the Heat yet encreases, so it Works and moderately Digests the Different Particles, and mixes them more exactly, (as we see in our Cohobations and Digestions,) which whets off the Roughness, and Blunts the Sharpness of the Saline Particles, and makes them less: Rarifying the Superfluous Moisture, and Precipitating the Earthy, Saline Matter to the Middle or Stone. So that those little Particles, being tempered with Spirit, and Sulphur, or Oyl, (which possibly after the Juices have had so long a Fermentation in the Pores, may be more plentifully supplied to the *Fruit*,) and by Agitation made Smooth, when they come to the *Sensorium*, do not affect it Violently, but by Titillation stir up a certain Pleasure, which we call *Sweetness*.

By what has bin said, it appears that the *Ætherial Particles*, are only a Procatartic Cause of these several *Tastes*, as they differently Digest, and

and Dispose the Particles in the different Seasons of the *Fruit*. But the Saline, and Spirituous, as they are Pungent and easily Dissolvable in the Water, or the *Oral* Humidity, and thereby insinuate themselves more deeply into the Membrane of the *Tongue*, seem chiefly to be the immediate Cause of these *Phænomena*. Tho' all Principles that are of a proper Density, and are Miscible with, or make an Alteration in the Humidity of the Mouth, will in proportion Affect the *Sensorium* of *Taste*; *Air*, *Æther*, *Odour*, being too Rare, will not, and *Glass* being too Dense and Indissolvable, cannot.

2^{dly}, It cannot be supposed, that all those Similar *Juices* that pass thro' the Organs of the *Plant*, and are thereby Modified as to Participate of its Nature, should immediately so adhere to the *Plant*, but that some loose Particles may be carried into the *Atmosphere*, along with the Stream of *Air* and Rarified *Juices*, that passes thro' their Tubes and Pores; and with it being drawn by Inspiration into the Nostrils, they will there strike upon its inner Membrane, and by the incongruity of their Particles, will so Irritate and Affect its *Fibres*, as to cause them to communicate the Impression by the *Nerves* to the *Brain*, and make that Alteration in the *Sentient*, (which the Soul that is capable of Judging, whence all the different Affections of the *Nerves* proceeds, perceives to flow from the Organ of *Smell*) which we call *Odour*. Which will be different, as the Composition and Modification of the *Plant*, from whence they flow is so.

3^{dly}, Because these Particles consist of Various Compositions, and acquire a different Texture in their passage thro' the Pores of *Vegitables*; as is evident

evident by their different *Smells*, therefore they cannot be supposed to be Similar to the Aerial Particles, and consequently not easily Miscible with them: And therefore they will be repell'd back by the Air, to the *Plant* from whence they flowed: Where entering by the Pores of the Body of the *Plant*, and with the *Juices* drawn in at the Roots, they make various Circulations, and are those *Effluvia* that form that Atmosphere, that is peculiar to every Particular Body, even to Pebbles, Glass, and Diamonds, as is evident by their Odour, when their Particles are Agitated by striking against each other.

Lastly, From hence it will follow that, that Body whose *Effluvia* are more Heterogenious to the Air, will have the more lasting Odour, and its *Dispendium* will be less; and for this Cause, I conceive it is, that *Musk*, *Civet*, and such like *Oleaginous Bodies*, a few Grains of which will Impregnate a large Space with such *Effluvia* (evident by their strong Odour,) for many Months, if not Years, without any sensible Decay: which can hardly be supposed, if those Particles were not repelled back again to their own Bodies, and from thence continued in a constant Circulation: Which will be made more plain when we come to *Electrical Bodies*.

This seems to be confirmed by Dr. *Woodwards* Experiments concerning *Vegitation*, mentioned in *Philos. Transact.* N°. 253. Where he says p. 198. 'I chose several *Glass Vials* that were all as near as possible, of the same Shape and Bigness; After I had put what Water I thought fit in every one of them, and taken an Account of the Weight of it, I strain'd and ty'd over the Orifice of each Viol, a Piece of Parchment, having an hole in the middle of it, large enough
to

to admit the Stem of the Plant, I designed to set in the Viol, without confining or straitning it, so as to impede its *Growth*. My Intention in this, was to prevent the enclosed Waters from evaporating, or ascending any other way, than only thro' the Plant to be set therein. Then I made Choice of several Sprigs of *Mint*, and other Plants, that were as near as I could possibly Judge, alike Fresh, Sound, and Lively. Having taken the Weight of each, I placed it into a Viol, ordered as above; and as the Plant imbib'd and drew off the Water, I took care to add more of the same, from time to time, keeping an Account of the Weight of all I added. Each of the Glasses were, for better distinction, and the more easie keeping Register of all Circumstances, noted with a different Mark or Letter, A, B, C, &c. and all set in a Row in the same Window, in such manner that all might partake alike of *Air*, *Light*, and *Sun*. Thus they continued from *July 26th*, to *October the 5th*, which was just 77 Days. Then I took them out, Weighed the Water in each Viol, and the Plant likewise, adding to its Weight that of all its Leaves that had fallen off, during the time that it had stood thus. And *Lastly*, I computed how much each Plant had gained; and how much Water was spent upon it. The Particulars are as follows,

(A) *Common Spear-Mint*, set in *Spring-Water*. The Plant weighed when put in *July 20th*. 27 Grains; when taken forth *October the 5th*. 42 Grains: So that in this Space of 77 Days, it had gained in Weight 15 Grains. The whole Quantity of Water expended during these 77 Days, amounted to 2558, Grains; consequently, the

Weight

Weight of Water taken up, $170\frac{2}{3}$ times as much as the Plant had got in Weight.

(B.) *Common Spear-Mint* set in *Rain-Water*.

The Mint weighed when put in Gr. 28 $\frac{1}{2}$; when taken out Gr. 45 $\frac{1}{2}$. Gained in 77 Days Gr. 17 $\frac{1}{2}$;

Water expended Gr. 3004; the Proportion of Encrease to the Expence as 1 to 171 $\frac{1}{2}$,

(F.) *Lathyrus, seu Cataputia Gerb* set in *Spring-Water* weighed when put in Gr. 98;

when taken out Gr. 101 $\frac{1}{2}$; Weight gained Gr. 3 $\frac{1}{2}$; Water expended Gr. 2501; the Proportion of the encrease to the expence of the Water,

as 1 to 714 $\frac{1}{2}$.

The Two Viols F and G were filled, the former F, with *Rain-Water*, the other with *Spring-Water*, at the same time as those above mentioned were; and stood as long as those did. But

they had neither of them any Plant; my Design in these being only to inform my self, whether

any Water exhaled out of the Glasses, any other way than thro' the Bodies of the Plants.

The Orifices of these two Glasses were covered with Parchment; each piece of it being perforated with an hole of the same bigness, with

those of the Viols above. In this I suspended a bit of Stick about the bigness of the Stem of

one of the aforesaid Plants, but not reaching down to the Surface of the included Water. I

put them in thus, that the Water in these, might not have more Scope to evaporate, than

that in the other Viols. Thus they stood the whole 77 Days, in the same Window with the

rest; when, upon Examination, I found none of the Water in these wasted or gone off. Tho' I

observed both in these, and the rest, (especially after hot Weather,) small Drops of Water, not unlike Dew, adhering to the Inside of the

Glasses

‘ Glasses, that part of them I mean, that was above the Surface of the enclosed Water. The Water in these two Glasses that had no Plants in them, at the end of the Experiment, exhibited a larger Quantity of Terrestrial Matter, than any of those that had the Plants in them did.

‘ Anno 1692. The Glasses made use of in this, were of the same sort with those in the former Experiment. The Plants all *Spear-Mint*, and ordered as the first. They stood from *June 2.* to *July 28.* which was just 56 Days.

‘ (H.) *Hide-Park Conduit-Water.* The Mint weighed when put in Gr. 127; when taken out, Gr. 255; Weight gain’d Gr. 128; Water expended Gr. 14190; the Proportion of the increase to the expense of the Water, as 1, to 11011.

‘ Q, R, S, &c. Several Plants set in Vials ordered in like manner, as those above in *October*, and the following Colder Months, these thrived not near so much, nor did the Water ascend in nigh the Quantity it did in the Hotter Seasons, in which the before recited Trials were made.

There are many other Trials made by Him, both in this, and the preceding year, which I shall omit for brevity, and proceed to the Reflections he makes upon the foregoing Experiments.

‘ *First*, He observes in Plants of the same Kind, the less they are in Bulk, the smaller the Quantity of the Fluid Mass in which they are set, is drawn off; the Dispendium of it, where the Mass is of the same thickness, being pretty nearly Proportioned to the Bulk of the Plant: thus that in the Glass Marked A, which weighed only 27 Grains, drew off but 2558 Grains of the Fluid; and that in B, which weighed only 281 took up

but, 3004 Grains, whereas that in H, which weighed 127 Grains, spent 14190 Gr. of the Liquid Mass.

He goes on, and says that Water seems to ascend up the Vessels of Plants in much the same manner as up a Filtre: But this cannot be admitted, for Heat is necessary to make it ascend (otherwise, it would descend by its own Weight as it does in *Autumn*, when it makes that selvage that is sometimes observed in the upper part, where the Bark of the Tree has bin pilled off round,) which he afterwards acknowledges p. 224, and proves it from the Plant that were set in the Glasses Q, R, S, in *October*, and the following Colder Months; which had not near the Quantity of Water sent up into them, or near the additional increase, as those set in *June, July, August*, and the hotter Months: and says farther, that Water has no Power of Moving it self, or rising to the Vast Height it does in the more tall and lofty Plants; which is manifest, for if it had power to ascend, as in a Filtre, it would ascend faster in the Winter (when it did not Freez,) than in the Summer; there being then a much greater stock of Water.

2dly, He observes, that much the greatest part of the Fluid Mass that is thus draw off, and convey'd into the Plants, does not settle, or abide here; but passes thro' the Pores of them and ex-ales up into the Atmosphere.

That the Water, in these Experiments, ascended only thro' the Vessels of the Plants, is undoubted; because the Glasses F, and G, that had no Plants in them, tho' disposed in like manner as the rest, remained at the end of the experiment, as at first, and none of the Water was exhaled or gone off.

O

3dly.

3^{dly}, That the greatest part of it Flies off from the Plant into the Atmosphere, is certain, because the least Proportion of the Water expended, was to the augment of the Plant, as 46 or 50 to 1: and in some the weight of Water drawn off, was 100, 200, nay in one above 700 times as much as the Plant had received in addition; which being caused to Evaporate thro' the Pores or Tube of Plants by the Heat of the Sun, exactly Quadrates upon our *Hypothesis*.

He goes on, and says, ' This so continual an Emission and Detachment of Water, in so great Plenty from the Parts of Plants, affords us a manifest reason, why Countries that abound with Trees, and the larger *Vegetables* especially, should be very obnoxious to Damps, great Humidity in the Air, and more frequent Rains, than others that are more open and free. The great Moisture of the Air was a mighty Inconvenience and Annoyance to those who first settled in *America*; which at that time was much overgrown with Wood, and Groves. But as these were burnt and destroyed, to make way for the Habitation and Culture of the Earth, the Air mended and cleared up apace, changing into a Temper much more Dry and Serene than before.

This seems to be very plain from what has been said before, for a Constant Circulation of the Air thro' the Tubes of Vegetables, like as thro' so many Tunnels or little Chimneys, may determine the Air to bend that way, where there are great Woods; which probably will cause the Clouds to incline that way also; and when they approach them, to descend in Rain. For as the Air descends to the Roots of the Trees from underneath the Clouds, so the Spring of the Air above

the Clouds will encrease, and press harder upon the Clouds, as the Aerial Particles sink from under it. As we may very sensibly, and with Pain find the Atmosphere to press upon our Hands, when the Air is drawn by the *Pneumatic Engine* under it; and consequently the superior Air pressing stronger upon the Clouds, where the inferior Air gives way, must break thro' and cause the Clouds to descend in Rain, like Water from a Cullender to the Earth: Where 'twill be again imbibed by the Roots of the Trees. And this is confirmed by an Observation of Mr. *Mills*, and others near *Welford* in *Warwickshire*, where from a little Hill, they have frequently observed a great Cloud to come directly over their Heads, and then it has separated, and one part has gone to a great Wood on one side, and the other part to a great Wood on the other side, where they have descended in violent Showers of Rain, whilst they betwixt them have had none at all.

'Nor does this Humidity (says he) go off pure and alone; but usually bears forth with it, many Parts of the same Nature with those whereof the Plant, thro' which they pass consists. The *Craffer* indeed are not so easily born up into the Atmosphere, but are usually deposited upon the Surface of the Flowers, Leaves, and other Parts of the Plants: Hence comes our *Manna's*, our *Honey's*, and other Gummous Exsudations of Vegetables. But the finer and lighter Partes are with greater Ease sent up into the Atmosphere. Thence they are convey'd to our Organs of Smell, by the Air we draw in Respiration; and are Pleasant or Offensive, Beneficent or injurious to us, according to the Nature of the Plants from whence they arise. And since these owe their Rise to the Water that ascends

ascends out of the Earth thro' the Bodies of
 Plants, we cannot be far to seek for the Cause,
 why they are more numerous in the Air, and
 we find a greater Quantity of Odors exhaling
 from Vegetables, in warm, humid Seasons, than
 in any others whatsoever.

3dly, A great Part of the Terrestrial Matter
 that is mixt with Water ascends up into the
 Plant, as well as the Water, is proved : First,
 Because there was much more Terrestrial Matter
 at the end of the Experiment, in the Water of
 the Glasses F, and G, that had no Plants in them,
 than in those that had Plants. 2dly, Because the
 Garden Mould dissolved in the Glasses K, and L,
 was considerably diminished, and carried off.
 3dly, Because a Plant is more or less Nourished,
 or Augmented, as the Water in which it stands,
 contains a greater or lesser quantity of proper
 Terrestrial Matter in it. Which is manifest, be-
 cause the Mint in L, in whose Water was dis-
 solved a small Quantity of Good Garden Earth,
 tho' it had the Disadvantage to be less when first
 set, than either of the Mints in H, or I, whose
 Water was the very same with this in L, but had
 none of the Earth mixt with it ; yet in a short
 time the Plant, not only overtook, but much out-
 striped those, and at the end of the Experiment
 was very considerably bigger and heavier than ei-
 ther of them. And the Mint in N, tho' less in
 the beginning, than that in M, being set in that
 Thick, Turbid, Feculent Water, that remained
 behind, after that wherein M was Planted was
 stilled off, had in fine, more than double its Ori-
 ginal Weight or Bulk ; and received above twice
 the additional Encrease, than that in M, which
 stood in the thinner distilled Water, and which

not less considerable; had not drawn off half the Quantity of Water that that had.

From hence he infers, *That Vegetables are not formed of Water alone, (as Helmont, and some others would have it,) but of a certain peculiar Terrestrial Matter.* And proves it thus, because the Plant in *E*, drew up into it 250 Grains of Water, and yet had received from all that but $3\frac{1}{2}$ Grains encrease. The Mint in *B* took up 39 Grains of Water, one day with another, which was much more than the weight of the Plant originally, and yet with all that it gained not $\frac{1}{4}$ of a Grain increase in a day.

But then, *2dly*, He shews, that there is a considerable quantity of this Terrestrial Matter contained both in Rain, Spring, and River Water, (and I may add in Air also, as is visible in those we call Moals in the Sun.) *And that Rain, and Spring Water contain near the same quantity of vegetable Matter; River-Water more:* Which he proves there at large.

3dly, He says, *That the Water it self makes no addition to Vegetables; yet 'tis a Vehicle to that Terrestrial Matter that does.* And proves it, by the Mint in *M*, which stood in the very same kind of Water as that in *N* did. But the Water in *M*, having much less Terrestrial Matter in it, than that in *N* had; the Plant bore up 8803 Grains of it, gaining it self only 41 Grains increase, in the time that that in *N*, drew off no more than 4344 Grains, and yet was augmented 24 Grains. So that that in *M*, spent 4459 Grains of Water more than that in *N* did; and yet was not it self so much encreased in weight, as that in *N*, by 53 Grains. He says (and I agree with him) that this is a very fair, and a very conclusive instance, and indeed they are all so.

He enlarges on the use of Water, and says, Water is not the Matter that composes Vegetable Bodies. 'Tis only the Agent that conveys that Matter to them; that introduces and distributes it to their several Parts for their Nourishment. That Matter is sluggish and unactive, and would lie Eternally confined to its Beds of Earth without ever advancing up into Plants, did not Water, or some such like Instrument fetch it forth, and carry it to them. That therefore there is that plentiful Provision, and vast Abundance of it supplied to all Parts of the Earth, is a Mark of a Natural Providence superintending over the Globe we Inhabit; and ordaining a due Dispensation of that Fluid, without the Ministry of which the Noble Succession of Bodies we behold, *Animals*, *Vegetables*, and *Minerals*, would be at a stand.

But then, he says, ' That the Concourse of ' Heat in this Work is really necessary, appears, ' not only from the Experiments before us, but ' from all Nature; from our Fields and Forrests, ' our Gardens and our Orchards. We see in *Autumn*, as the Sun's Power grows gradually less, ' and less, so its Effects upon Plants is remitted, ' and their *Vegetation* slackens by little and little. ' Its Failure is first discernible in Trees. These ' are raised highest above the Earth; and require ' a more intense Heat to elevate the Water, charged with their Nourishment, to the Tops and Extremities of them. So that for want of fresh ' Support and Nutriment, they shed their Leaves, ' unless secured by a firm and hardy Constitution ' indeed, as one *Ever Greens* are. Next the ' Shrubs part with theirs; and then the Herbs, ' and lower Tribes; the Heat at length being not ' sufficient to supply even these, tho' so near the ' Earth, the Fund of their Nourishment.

As the Heat returns, the next succeeding Spring, they all recruit again ; and are furnished with fresh Supplies and Verdure : But first, those that are Lowest and Nearest the Earth, Herbs, and they that require a lesser Degree of Heat, to raise the Water with its Earthy charge into them : Then the Shrubs, and higher Vegetables in their Turns ; and lastly, the Trees.

As the Heat Increases, it goes too powerful, and hurries the Matter with too great Rapidity thro' the finer and more tender Plants : These therefore go off, and decay ; and others that are more hardy and vigorous, and require a greater share of Heat, succeed in their Order. By which Mechanism, provident Nature furnishes us with a very various and different Entertainment : and what is best suited to each Season, all the Year round. Nor is it the Sun, or ordinary Emission of the Subterranean Heat only, that promotes Vegetation ; but any other indifferently, according to its Power and Degree : This we are taught by our Stoves, hot Beds, &c. All Heat is of like kind ; and wherever is the same Cause, there will constantly be the same Effect. There's a Procedure in every Part of Nature, that is perfectly Regular and Geometrical, if we can but find it out ; and the further our Searches carry us, the more shall we have occasion to admire this, and the better 'twill compensate our Industry. *Vid. the Author.*

All which perfectly agrees with our Hypothesis ; which places a Similar Juice, (or Water impregnated with Terrene, Saline, Sulphurious Particles, &c.) to that contained in the Pores and Tubes of Vegetables, in a Liquid form at their Roots ; which being Similar, is easily forced into them by the Pressure of the Air or Atmosphere. As the

Heat of the Sun, causes the Watry Part of the Juice in those Pores or Tubes, already contained to Evaporate, and being modified by those several Pores, as it passes farther, and digested by the Heat of the Sun, is Assimilated into the Plant.

6thly, As the *Ætherial* or *Solar Particles* strike upon the Skin and enter its Pores, and by their Activity purify the Juices therein contained, and cause them to take up more room; so they gently Agitating and Attenuating the Blood and Juices they cause them to circulate more easie in their Vessels: which being useful to the *Animal*, its Life depending upon their due Circulation, Causes that acceptable Sensation in that Organ which we call *Warmeth*; which being more violent is *Heat*; if with so much Violence as to dilacerate its Pores, and dissolve the continuity of its Particles, 'tis Burning or Painful. So that those Impressions upon the Senses that tend to the Promoting or Continuing the Union betwixt Soul and Body are Grateful and Pleasant: those that tend to the Diffunion of Soul and Body are Ingrate and Painful. Its possible more may be said upon this Head; but I shall proceed to the Second, and account for the Phenomena that result from, or are caused by the Solar Particles as they are Elastic and Springy, or capable of being reflected and expanded always supposing their proper Rotatory motion to be continued.

C H A P. XXV.

AND as such I conceive they will account
 1st, For Sight. 2dly, For Colour. 3dly, For
 Refraction.

First,

First, These *Elastic* and *Expansive* Particles being darted from the Body of the Sun, in right Lines, or somewhat Refracted by the Air; and numerously and violently entring the *Tunics* of the Eye, by their *Expansive* Power and Rotatory Motion do agitate and dilate the Humours therein contained; and beat upon the most sensible Tunicle of the Eye called the *Retina*, which communicates the Impression to the *Spirits* (those quick Messengers of the Soul,) in the *Optic Nerves*, which makes such an Alteration in that *Sensorium*, which being observed causes the *Phantasie* of a Lucid Body in the *Sentient*.

2dly, As the *Solar Particles* are darted from the Sun, so they are capable of being Reflected from any Body they fall upon (as has bin shew'd before, and the cause why) and if they fall upon a Body whose Superficial Particles are Solid, Flat and Homogenous, they will be Reflected back again to the Eye (if it be placed in their Line) in the same manner that they fell upon that Body; or as they would have done if the Eye had bin in the place of that Body; and because they enter the Eye in the same manner, they will cause the same Alteration in that Organ: which being so represented by the *Spirits* to the Soul, will cause the same *Phantasie* of a Lucid Body in the *Sentient*, and thus they are Reflected from a Polished Metallic *Speculum*, or from the Foil of a Looking Glass. And this is the cause why we see the exact Lineaments of the Face in the Glass, viz. because the Rays that result from every Particle of the Face to the Glass, are Reflected back exactly in the same manner from the Glass to the Eye; and consequently affect the *Sentient* in the same manner as they would have done, if the Eye of the *Sentient* had bin in the place of the Glass.

But

But if the compound Particles in the Superficies of the Body, are Dissimilar, some Flat, some Concave, some Convex, some Acute, others variously compounded of all these; as in the Figure, Suppose *A* the Eye, *B* the Sun, *C D* the Superficies of a Body, in which *e* is a Concave Particle, (or the smallest distinct Part in the Superficies of



the compound Body,) from whence the Solar Rays being Reflected will Converge: *f* a Convex Particle, from whence the Solar Rays being Reflected will Diverge; the Solar Particles being Reflected from a Convex, or Concave in the same Line as they would from the Tangent of that Convex or Concave; the Obliquity of the Convex or Concave being equal to the Obliquity of the Tangent of the Convex or Concave: *g g g g* being Flat or Plain Particles of the Body, will Reflect the Rays of the Sun to the Eye in Parallel Lines: *i* being Acute, the Rays will fall on its sides Obliquely, and consequently they will be Obliquely Reflected in an Angle equal to the Angle of Incidence: *k* being Acute, Concave and Convex, will have the Affections of all of them: *l* is Convex on one side, and Concave on the other; by which the Rays Reflected on one side, would Diverge, on the other Converge; and both Obliquely, or in a way different from that of the Eye.

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By which 'tis evident, that the Solar Rayes Reflected from such a Body would variously, and confusedly cross each other; and many of the Ætherial Particles that fell upon it, would be so Obliquely Reflected, and thereby scattered as never to come near the Eye. Wherefore, First, They cannot enter the Eye in the same Numbers as they would from a Looking-Glass; where the same are Reflected back in Parallel Lines that fall upon it: and therefore they cannot affect the Eye with so much Force. Nor, 2dly, In the same manner, because they confusedly cross each other; so that the Ray, that would affect the right side of the Eye at *n*, if it were Reflected from a Plain or Flat, being Reflected from a Concave, falls upon the left side of the Eye, and Affects it at *m*; so on the contrary.

And because the Ætherial Particles are thus irregularly or confusedly Reflected from the Superficies of such a Body, they will enter the *Tunics* of the Eye, and be Refracted by the *Christaline* Humour in a different Manner, and with less Force; and entering it thus differently, will differently Affect it, and consequently make a different Alteration in the Sentient, which we therefore give a distinct Name to, and call it *Colour*.

And, 2dly, Because all the Species of *Vegetables*, *Animals*, and *Minerals* consist of different Particles, and have different Modifications, and Proportions in their Compositions; therefore the Particles in their Superficies will be differently Figured, and the Sun-Beams from thence differently Reflected, which being received into the Eye, will differently Affect the Spirits in the *Optic Nerves*, whose Business it is, to represent to the Soul Impressions, different as they are made. Which because it can distinguish, it gives divers Names

Names to, and calls this *Red*, that *Blue*, another *Green*, &c. So that the *Colour* of Things seems to be nothing else but *Light* Partially and Irregularly Reflected, from the Particles in the Surfaces of Bodies : which as they have Power, by reason of their Figures, to Reflect more or less ; so they more or less Affect the Eye ; and therefore cause the Phantasie of a Lighter or Darker *Colour*, or more or less approaching to Lucid, as the Light by them is more or less scattered.

This seems confirmed by many Experiments : First, If you set your self so as to see the Image of the Sun upon Glass Windows, Water, &c. and place any Opaque Body betwixt your Eye and that Illuminated Point, so as to let but few of the scattering Rays of Light fall from thence on the Eye, they will appear Coloured like the *Rainbow*, and the Colours will be Lighter or Darker, as you admit more or fewer Lucid Particles to the Eye.

2dly, If you look thro' the Wings of Birds, as of the *Lark*, *Woodcock*, &c. or Black Silk at the Sun, Fire, Candle, or any other very Luminous Body, you will see the Colours of the *Rainbow* ; the Luminous Particles being but partially admitted thro' those Pores.

3dly, If you look long upon any Luminous Body, and then turn away your Eye, and Wink, you will seem to see the Object, first of a Light Yellow, afterwards Red, then Crimson, afterwards Purple, or of a Dark Green, and so darker and darker, as the Impression is greater or lesser, that is, as the Eye is affected with a greater or lesser Number of Lucid Particles.

But here I again find, that Great Author Mr. *Newton*, setting up a different *Hypothesis* from mine ; and seeming to prove it by Undoubted De-

Demonstrations, an Abstract of which was communicated to me by my Worthy and Ingenious Friend Mr. *John Perks*, Governour of Mr. *Foley's* Hospital at *Old Swinford*; and is as follows.

- I. *Light* consists of an infinite Number of Rays Right lined, and Parallel; but of Different Degrees of Refrangibility, when meeting with a different Medium. *Newton's Opticks, Pag. 13. Prop. 1. Theor. 1. and Pag. 18. Prop. 2. Theor. 2. Pag. 22.*
- II. Each Ray according to its Different Degree of Refrangibility, when so Refracted, appears to the Eye of a different Colour.
- III. The least Refrangible Rays, appear of a deep *Scarlet*, the most Refrangible appear of a *Violet Blue*, the intermediate proceeding from *Scarlet* to *Yellowish*, then to light *Green*, and so to *Blue*.
- IV. The Colours arising from the different Refrangibility of *Light*, are not only the more noted Colours of *Red*, *Yellow*, *Green*, *Blue*, but also all the intermediate Degrees of *Red* to *Yellow*, of *Yellow* to *Green*, &c. differing as the Degrees of *Sound* from Grave to Acute, in which there are not only the Notes of common Denomination, but also indefinite intermediate Degrees of *Sound*, which are as different Sounds as the other.
- V. *Whiteness* (such as the Sun's *Light* appears) containing all these Degrees of Refrangibility, is consequently made up of all the above mentioned Colours.
- VI. Simple or Homogenial Colours are such as are produced by Homogenial *Light*, or Rays, that have the same Degree of Refrangibility; and mixt Colours are such, as are pro-

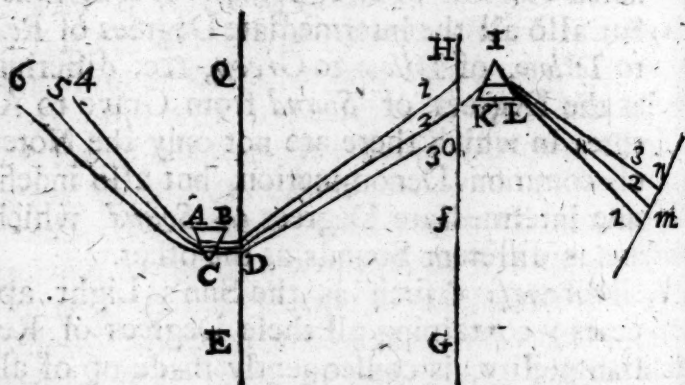
produced by Rays of different Refrangibility.

VII. Rays of the same Refrangibility produce the same Colour, which Colour is not alterable by repeated Refractions, only made more strong or faint as the Rays are united or scattered.

VIII. All Bodies appear of this or that Colour, according as their Surfaces are adapted to Reflect only the Rays of such a Colour, or (at least) in more plenty than the rest.

First Experiment for Confirmation of the foregoing Doctrine.

The great Experiment on which Mr. Newton grounds his Doctrine, (and which he calls *Experimentum Crucis*) is after this manner : *B E* and *F G*, are Two Boards about four or five Yards Distance, having in each of them a little round Hole at *D* and *H*, of about $\frac{1}{4}$ of an Inch Diameter.



*Newton: Opt.
Exprim. 6.
Pag. 30, 38.
Fig. 21.*

A B C is a Prism exposed to the Sun, *K L* is another Prism, whose side *I K* is near Parallel to the side *B C* of the other, and receiving the Rays

Rays DH , Refracts them to fall on a Paper MN . The Colours will fall from H to O on the Boord FG : let one only Colour (suppose the Blue) fall on the Hole H , and it will be Refracted by the Prism IKL to fall (suppose) at M , then move the Glass ABC about its Ax so as to bring another Colour, suppose the Red at O to the Hole H , and it will by the Glass IKL be Refracted not to M , but another place (suppose N) some Distance from the other, and in like manner will each Colour be Refracted to fall in a different place, tho' the Glass IKL be held unmoved.

This *Experiment* proves the different *Refrangibility* of the Rays of Light, and that different Colours do thence arise.

For the Holes D and H being fixt, and also the Glass IKL , 'tis plain, that the Rays have a like Incidence on the Glass IKL , but the different Places where they fall on the Paper, as M , N , &c. shew a Different Refraction in the Glass IKL ; and the Eye discovers a different Colour, according to the different places on which the Rays fall, which demonstrates the Fundamental Doctrine of the Theory.

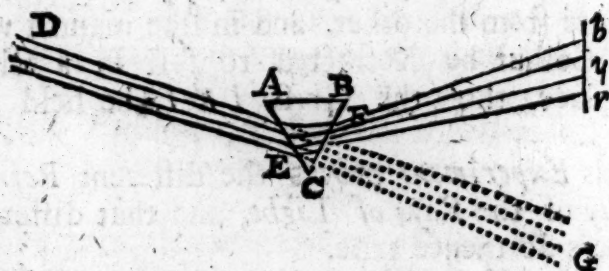
Mr. *Newton* directs this to be done in a dark Room, where, no doubt, all will appear more exact and lively. My Tryal (for want of Conveniencies) was in an open Room, but it succeeded well enough to satisfie me of the Truth.

He observes, that the oblong Image of Colours HO will be about five times its breadth, which also shews the different Refrangibility of the Rays, otherwise the Image would be near round as the Hole D is.

Second

Second Experiment.

Being in a convenient Room where the Sun shines thro' a Hole or open Casement, turn your Back towards the Sun, and hold the one end of the Prism so to your Eye, that the Sun may shine



on the other end ; then move it so about its Ax, that the Colours may appear somewhere on the Wall ; find the Colours with your Eye looking thro' the Glass, and there will appear a Spot of perfect Light.

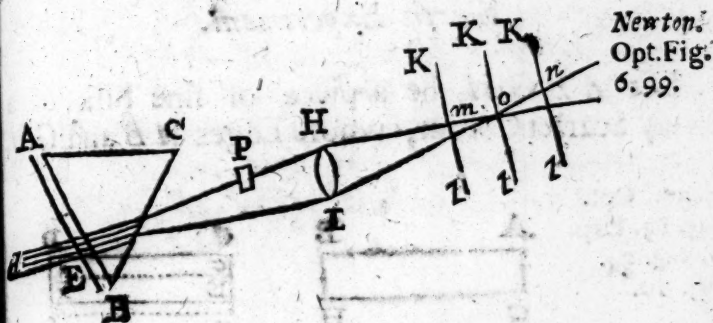
The reason of this Appearance is this : the Parallel Rays D E, meeting with the Glass at E, and again with the Air at F, are separated by these two Refractions, the least *Refrangible* appear Red at r, and the most *Refrangible* appear Blue at b, with the intermediate Colours between. These Colours being viewed by the Eye at E, the Rays come back (near) the same way they went, and are therefore in like manner united at the Eye, as they were in their *Incidence* from the Sun, and consequently have the same Appearance (*White*) as the Light it self. The place where the Spot of Light Appears to the Eye at G, where the Rays would have fallen, had they not bin intercepted, and of a bigness according to what

Light

Light falls upon the Glass, whereas the Coloured Image *by r* will appear four or five times longer, by reason of the scattering of the differently Refracted Rays.

Third Experiment.

ABC, is the Prism, upon one of whose sides is put a Past-board, Thick-Paper, &c. with a little round Hole at *E*, which being exposed to



the Sun's Rays *DE*, they are Refracted and carried (in Colours) towards *HI*.

HI is a Lens (or Convex Magnifying Glass) broad enough to receive all the coloured Rays, which being made to converge by the Glass, they will be united in *O*, the Focus of the Glass.

Hold a piece of Paper *Kl* in the Focus, where all the Colours are united, and the little Spot at *O* will be perfect Light or Whiteness: but if the Paper *Kl*, be held farther or nearer (as at *M* or *N*) the Colours will appear. If any of the Colours be intercepted, as at *P*, the Light near *O* will not be clear White, but inclining to the remaining Colours. If the Blue be wanting, the White will be somewhat Reddish or Flesh-Colour; and if the Red be wanting, the White will be somewhat Bluish: and if only one Colour be let come to the Lens,

P

that

that Colour without Alteration, will be transfer
red to the Paper *K L*.

This Experiment shews, (1.) That all the
Colours being united make Light or Whiteness.
(2.) That if any Original Colour be wanting,
the White will not be pure. (3.) That a Sim-
ple Colour is not alterable by farther Refractions;
which also will appear if another Prism be
put at *O*.

Fourth Experiment.

Let *ABGH*, be a piece of fine Silk of a
lively Scarlet Colour, whose Edges *AB* and *GH*,

Newt. Opt.
pag. 13. Exp.
1. pag. 34.
Fig. 20.



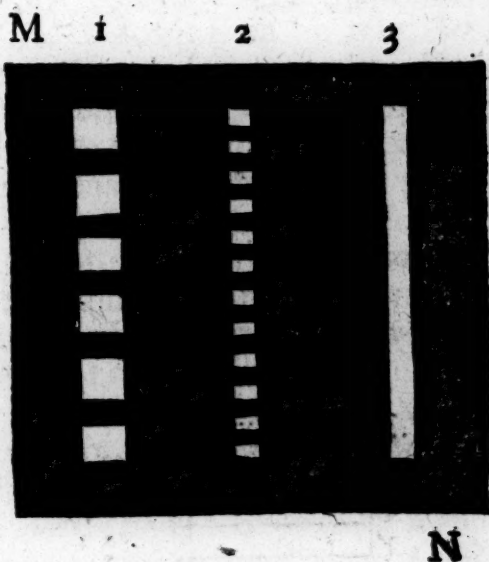
are strait, Parallel, and smooth; let *CDEF*,
be another piece of Violet Blue Silk, like and
equal to the other.

Let them be placed as in a the Figure upon
some Black Cloth or Door, with their Edges in
a Strait Line. View them thro' a Prism at a-
bout two or three Yards distance. The Ax of the
Prism being parallel to the Position of the Silks.
So will the Blue piece *C F*, appear lower than
the other, (*viz.*) as in *c d e f*. The Reason of
which appearance is, that Blue is more Refrangible
than Red. This will more fully appear, if
instead of the Blue Silk *C F*, there be let in the
place of *C F*, the Blue Rays from another Prism
(the other Colours being intercepted by a Paper

with a square Hole for the Blue to pass thro'.
If the Silk A H, and the Blue Square C F be
viewed thro' a Prism, as before, the Blue will
appear far below, as at K L, this being a more
perfect Blue than any Silk can be of.

Fifth Experiment:

Let *M N* be the Black Cover of a Book, Paper
coloured Black, &c. upon which lay in a strait
Line, 5 or 6 little Squares of White Paper, a-
bout the bigness and at the distance, as in the
Figure, first Column. View these thro' a Prism,
so as that the Row of little Squares have its one
end towards you, or be in a Plain perpendicular
to the Ax of the Prism, and about two Feet di-
stant from the Glas; so will you see a Stream



Colours proceeding from every Square, to-
wards the next nearer you, the Colours arising
at of each White Square. Move these Squares
P 2 nearer

nearer to one another, or put others between them, as in the second Column, , (still keeping them in a Strait Line,) and you will see as they come nearer, that the Colours mixing one with another, will alter, approaching nearer to White, till the Squares touch : And then all the Colours being perfectly Mixt, they produce Whiteness, and appear as in the third Column, a White Line, only tagg'd with Red at the Top, and Blue at the bottom, there being no other Colours coming from above to mix with the uppermost Red, nor any Colours below the Blue at bottom for it to mix with.

If you turn the Paper M N, aside a little from its Perpendicularity to the Glass, the third Column, which before appeared White, will all appear in Colours arising out of the White and Streaming towards you, they being always in a Plain Perpendicular to the Axis of the Prism.

From this Experiment, and the foregoing Doctrine, we have the Reason why a Sheet of White Paper, &c. appears Coloured only at the Edges; For there only the Colours want others to mix with them: In the Middle, taking any Point, the several Colours from so many other Points meet there and make White; for Instance,

Let *rr* be any little Particle in the Middle of

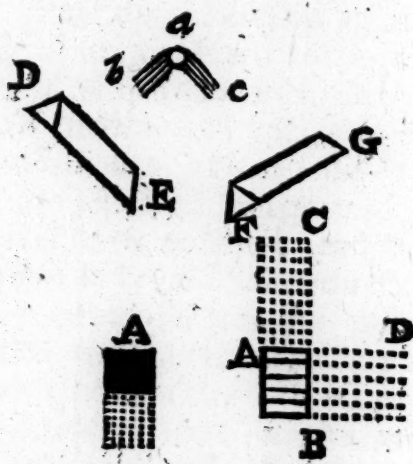


a White Surface, whose other Colours Stream

ing towards B leave the Particle rr its self Red, as the Squares will do in the last Experiment. The Yellow of the Particle yy , the Green of the Particle gg , the Blue of the Particle bb , do all meet on the Particle rr , which is Red. (For if bb were a White Particle, and all Black about it, its Blue Colour would by seen upon rr ; and if gg were another, its Blue would be below rr , and its Green upon it, &c.) and so there being a concurrence of all the Colours that make up White, it consequently appears White. The same may be said of any other Particle lying so far from the Edges, as to have the other Particles between to transmit their Colours.

- If a Square Paper be held so Strait before you, that the two Side Edges, be in a Plain Perpendicular to the Axis of the Glass, they will be White, and no Colours appear but at the top and bottom, the Streaming of the Colours, being in such a Perpendicular Plain; as may be observed by looking at any White Spot thro' the Glass, and then turning it a little obliquely to the Horizon, or one end higher than the other.

So in the Position of the Glass D E, the White Spot ascends its Colours towards b ; and in the Position F G, the Colour stream from a to c . If a Black Spot as A, upon a Paper, be viewed thro' the Prism, the top will have Green and Blue upon it, and under the lower part will appear Red and Yellow: The Reason of which is, that the Blue comes from the White above it, and appears on the Black, there being no other Colours to mix with it: The Red appears under the Spot, because the Black Spot transmits no other Colours to mix with the Red.

*Sixth Experiment.*

Hold the *Prism* so to the Sun, as that the Colours may appear upon a large Plain Wall, as at A B, turn the *Prism* swiftly about its Axis, so as that the Colours may move swiftly up and down, as from B to C. So will there appear no Colour distinct, but a faint White Streak between B and C, which so appears, because by the swiftness of the Motion, the several Colours are confounded, and mixed, and therefore appear White. Then move the Glass in such a manner, that the Colours may move side ways and Swiftly as from B, to D, in which Case the Colours will not disappear, but make a sort of List of several Colours, because they are not mixt to make Whiteness, but each Colour keeps in its own Line.

Seventh Experiment.

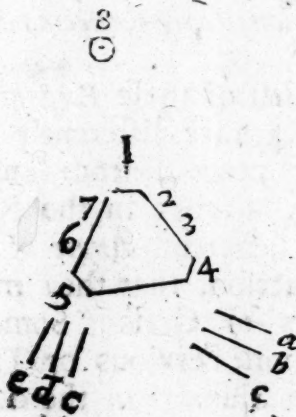
In a dark Room, having a little Hole for the Sun's Rays to come in, apply the *Prism* to the Hole

Hole, so as that the Colours may appear upon a Wall. Hold a quantity of *Smalt*, *Powder Blue*, or *Blue Silk* in the Colours severally, and it will appear clear of the Colour of the Rays that falls upon it, (*viz*) *Red*, while the *Red Light* falls upon it, and *Yellow* while the *Yellow Light* falls upon it; but of all the Colours, 'twill most strongly affect the *Blue*, the Surface being most disposed to Reflect those Rays, &c. Then View a quantity of *Vermillion*, or a little piece of *Scarlet-Silk* in the *Blue Light*, and 'twill appear *Blue*, and *Green* in *Green Light*; but of all the Colours, 'twill most strongly reflect the *Scarlet Rays*, and appear deepest of that Colour. This Experiment confirms the Eighth Proposition, That Bodies appear of the Colours of those Rays, that are most plentifully Reflected from the Body to the Eye.

From the First of these Experiments 'tis granted, that the Rays are differently Refracted; but this does not proceed from any difference of Refrangibility, that is in the Rays themselves, but from the different Angle of Incidence, and different Refraction, that they meet with in the different parts of Glass: Some parts of the Glass being more Pervious or Transparent than others, or the Sides than the dead Edges, that are ground off so as to make them Opaque; by which the Rays that fall upon them are scattered, and hindered from entering the Pores of the Glass, and therefore the Light nearest that part will be most lessened, and consequently make the darkest Colour; which because it happens to be from the most Acute Angle, will be also most Refracted, and therefore make the most Refracted darkest or *Blue Colour*: Those that fall next to these being less scattered or

shaded by those Edges, make a Lighter or Green Colour : Those that fall farthest off, upon the thickest Part of the Glass, being least diminished and least Refracted, make the lightest or Red Colour; tho' there are sometimes intermediate Colours, that sometimes seem Lighter than this, some of the Rays of this being lost in the opposite dead Edge.

As suppose the Figure to be a Prism, whose Angle *i*, is fully exposed to the Sun 8, 'tis plain that the Space betwixt 1 and 2, will be more shadow'd by the Dead Edge at the Angle 1, than the Space betwixt 2 and 3, and this more than the Space betwixt 3 and 4, and consequently the Colour that results from the Re-



fracted Rays that fall in the space betwixt 1 and 2, will be darker than those that fall in the Space betwixt 2 and 3, and these than those that fall betwixt 3 and 4, (tho' some of these being scattered or absorbed within the Glass by the dead Edge at the Angle 4, make it appear less Luminous at *c*, than some of the intermediate Colours.)

2dly, 'Tis plain that in the Figure, in Mr. New-

ton's

ton's first Experiment, 4 D Q makes a more Acute Angle, than 5 D Q or 6 D Q, and consequently the Angle 1 D Q, (which bears a proportion to the *Angle of Incidence*,) will be more Acute than 2 D Q or 3 D Q; and therefore if the *Prism* A B C, be so far turned upon its Axis, as to bring the Ray 6 D, to 7 D, and consequently the Ray 3 D to the Ray 2 D, and from thence thro' the Hole H, to the *Prism* I K L, the Ray 3 D, will not be Refracted by the *Prism* I K L, to M, but to N; because the Ray N H proceeds from the Ray 6 D, which makes the more Obtuse *Angle of Incidence* 6 D Q, to which the Angle N H G bears a proportion, and so 1 D Q, to 4 D Q: which does not proceed from any difference in Colour or *Refrangibility* in the Rays of Light, but from the different Inclination of the Rays, by which they are differently *Reflected* or *Refracted*.

For if the Rays themselves have different Colours, they must proceed in different Colours from the Sun, in the same manner that they fall upon the Glass, which is *Stratum Super Stratum*, or a Layer or Row of Red, another of Green, another of Blue as they are *Refracted* from the *Prism*: for every part of Glass is Glass, and its Particles and Pores are Uniform, and the same in one part as the other, and therefore can make no diversity, but will suffer the Red Green, or Blue Rays to pervade them, as well in one part as another, if they fall upon it; the Pores and Particles in the Surface being the same as to Figure and Magnitude, in the thickest as in the thinnest part of it, and therefore can have no greater an aptitude to receive, or reflect one Colour than another, or to separate one Colour from the rest, more in the thickest than in the thinnest part of the Glass.

And

And if they do proceed thus in Rows from the Sun, as we see they are Refracted from the *Prism*, -all Bodies that have uniform Pores or Particles in their Superficies, (as most Bodies have Pores uniform in all its Parts to themselves,) must appear Striped, as we see those that receive their Colour from the Rays Refracted from the *Prism* do: For different Colours Reflected from the same sort of Particles, cannot make the same Alteration, or *Idea* in the Organ of *Sight*. Besides if these Colours should proceed from the Sun in Rows or Stripes, as we see them from the *Prism*, it would be difficult to give a Reason why the Blue or most Refrangible Rays of Light always fall upon the thickest part of the Glass; the Red or least Refrangible Particles upon the thinnest; the Green, on intermediate Parts of the Glass: tho' you move it to the right Hand or left, higher or lower on purpose. Wherefore 'tis evident that the different Colours are not in the Rays themselves, but result from the different Refraction, and dissipation of the Solar Particles, as they pass thro' the Glass, and if so, His Great Experiment, which He calls *Experimentum Crucis*, proves nothing.

His Second *Experiment* makes directly for us; for the Ray's of Light that fall upon the Glass at *e*, and by it are so scattered, lessened, and differently Refracted, as to take up four or five times as much space betwixt *b* and *r*, as they did at *e*, being Reflected thus confusedly, scattered, and lessened, (all the Light that falls upon the Glass, being not Refracted, but part of it glancing from the flat sides, is Reflected into those two White or Lucid Spots we see at a distance from the Colours,) from *b y r* to the Eye, must cause an Alteration in that Organ, different from what

what they would have done, if the Eye had bin placed instead of the Glafs at e ; and if they then caused the Fancy of a Lucid Body at e , they must cause the Phantasie or Idea of Colour at r , they appearing different to the Eye from hence, which difference we call *Colour*.

But if we look thro' the Glafs at e , upon the Colours $b y r$, those Rays coming back the same way they went, will be again united by the Glafs at the Eye, and will enter it in the same manner, and with the same Force at e , as they would have done if the Glafs had bin away, and they had there fall upon the Eye; and consequently cause the same alteration in that Organ, or Fancy of a Lucid Body, or Spot of Light of the same bigness, (or not much different) from that which fell upon the Glafs.

Which will appear to the Eye, being there placed in a right Line with $d e$, as at g , because they are Refracted or proceed from the Glafs to the Eye in that Line.

Max. 7.

p. 12. fig. 3.

The Third Experiment proves what we have said before, that Light scattered is Colour, or the Rays of Light $d e$, falling upon the Glafs $A B C$, and by it being scattered so as to take up five times as much Space at $I H$, will there affect the Eye in a manner different from what it did at E ; but being again collected by the *Lenticular* Glafs $I H$, into the same compass they were at E , upon the Paper $K L$, held at the *Focus* O , they will there again have the same Force, and Affect the Organ of Sight in the same manner as they did at E , and consequently cause the same *Idea* or Fancy of a Lucid Body; and is no more than $ab + c - c = ab$.

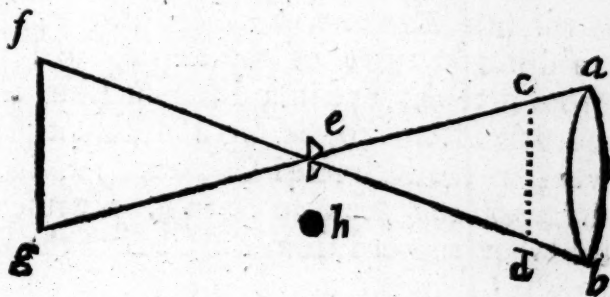
But

But if the Paper K L be held nearer or farther off, (as at M or N,) the Colours will appear, but lighter or darker, that is, fainter or stronger as they are nearer to the *Lens* I H, or farther from the *Focus* O, that is, as the Rays are more or less dispersed. If the Blue or Red are intercepted, $\frac{1}{3}$ of the Luminous Rays will be intercepted, and consequently it cannot be supposed that the remainder should Affect the Eye with the same Force, or in the same manner as the whole, except they are more collected or nearer the true *Focus*; and then I could never find, but if they were numerous enough to cover the *Lens*, but in the true Point of Convergency they would be perfect Lucid, as if all had bin collected.

If the Red and Green, or Green and Blew Colours be intercepted, $\frac{2}{3}$ of the Luminous Rays will be intercepted; and then the remainder will be so few, and will fall upon the Lens in such a manner, that they cannot all be collected into a Point, but some by a good thick Glass may, and those will appear Lucid, tho' in a Point no bigger than a Pin's-Head. This will appear much more plain in a Green Lens, (as suppose a Spectacle or Reading-Glass,) thro' which all the Solar Rayes will appear upon a Paper held near it, of a Greenish Colour; but in the Point of Concourse perfect Lucid. The Green Colour in the Glass, I conceive proceeds from its having its direct Pores obstructed, so that the Solar Rays in their passage thro' it, are scattered, and possibly some of them Totally hindered: (which seems probable, because they will not easily Burn,) by which they appear of a different Colour from those that pass without any let thro' a clear Glass, and not because that Glass has

power

power only to separate the Green Rays of Light, (as Mr. *Newton* would seem to have it :) For if so, how comes the Rays that have passed the Green Lenticular Glass *a b*, and are Green at *c d*, to change their Colour in passing to *e* the Focus, and there to appear Luminous upon the same White Paper that they appeared Greenish



on before at *c d*: And if they proceed to *f g*, where they are again Scattered, they will again reassume their Greenish Colour: and again if you move the Glass so as to make the White Spot in the Focus at *e*, to fall upon the Black Spot at *b*; how come they to appear there Coloured inclining to *Orange*? If you say at *b*, it wants the White at *e* to make it Luminous, how comes it to be Green at *c d*, when it has that White?

The true Reason seems to be, because at *c d* the Solar Particles are scattered, at *e* again collected, at *b* absorbed, or at least so obliquely Reflected as not again to affect the Eye, which latter probably is the cause of Blackness: As seems to be confirmed by that *Microscopic Experiment* of Mr. *Hook*; Where he observes that a Cole is extremely Porous, above any thing that he could meet with, which made him very well conclude, that the Light which is Reflected from more continuous

tinuous Bodies, was lost in those Pores, and therefore the Cole appears Black.

The Reason why the Blue Silk being viewed thro' a *Prism*, in the Fourth *Experiment*, appears lower than the Red, is not, I conceive, because the Blue Rays are more *Refrangible* than the Red; but because they are Refracted from a more Acute Angle than the Red, (as I have shewed in the first *Experiment* :) and therefore fall upon a different part of the *Prism*, and proceed from it to the Eye in a different Line, and consequently seems to be in a different place, or lower; as the Refracted Colours *by r*, in the second *Experiment* seem to be in *g*, because the way that they proceed from the Glass to the Eye, is in a right Line with *g*.

The Fifth *Experiment*, shews (as the rest,) that Light scattered is Colour, thus the Light Refracted from each White Square, falling upon the *Prism*, and by it being scattered, appears to the Eye in Colours proceeding from the Square, and taking up so much more Room, as to extend it self over the intermediate Space betwixt each Square, upon which intermediate Space, being darker they easily appear. But if those intermediate Colours fall upon a Spot equally Lucid, with the Spot from whence they arose, the defects of those scattered Rays, being overcome or supplied by the Lucid will disappear.

And here the next Square Spot being equally Lucid with that from whence those Colours arose, if moved up to the other, in that intermediate Space where the Colours fall, cannot be supposed to be made more dark, by having some of the other Rays cast upon it; and therefore if all the intermediate Spaces, are all filled up with Spots equally

equally Light, they must all remain so; because, what one looses by having its Luminous Rays scattered by the *Prism*, falls upon the other, and therefore taken altogether, they will be the same; the ends being only tagg'd with Colours, because there it being darker, the scattered Rays will be lessened, and therefore appear Coloured.

If you turn the Paper M N, aside a little from its Perpendicularity to the Glass, the third Column which before appeared White, will appear in Colours; because the Rays reflected from the White to the *Prism*, are by it scattered towards you, so as to seem to extend themselves over the Black, and appear in Colours, which is always in a plain Perpendicular to the Axis of the Glass: because that way only, the *Prism* is capable of extending them farther than the White, by variously Refracting them.

The Sixth, as far as I can make the *Experiment*, seems to be a mistake; for which way soever you turn the Glass, if it be done with Celerity, the Colour appears very faint and confusedly; but yet it does appear, if you turn it no farther than it will appear, if you turn it slowly: but if you turn it quite round the Axis swiftly, the three White Spots of Light that glance from the Flat-sides of the *Prism*, will make a continued Circle of Light: Not because the Colours are mixt, but because the Impression made in the Eye from any Point, will last till the Luminous Object comes to the same Point again; as Fire upon the End of a Stick Swiftly turned about, will seem to make a Circle of Fire, for the same reason: But if it was as he affirms, it proves no more, but that Light scattered, appears in Colours, but Lucid if again collected.

The

The *Seventh Experiment*, proves that Bodies appear of that Colour that the Rays cause, that are most plentifully Reflected from Similar Particles, and in a Similar Angle, from the Body to the Eye.

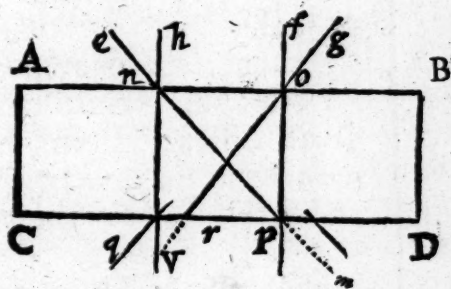
The *Figure* of every Body is represented to the Eye; because the *Solar Particles* are hindred or Reflected from all parts of every Body they fall upon, and therefore they will either, being Reflected from all parts of the Body, make an Impression of every part, and consequently the *Figure* of every part in the Eye. Or else the Rays being hindred by all parts of a Body betwixt the Sun, or a Candle and the Eye, will cause an Opacity or Shade in the Eye, of the same *Figure* of the Body that hinders the Rays from the Eye, and of no other: As for Example, the Rays Reflected or hindred by a *Triangle*, will make a *Triangle*, not a *Globular Figure* of Colour or Shade in the Eye; because a *Triangle* is deficient in some Parts required to make it *Globular*, and where Body is deficient, or where there is no Body, there can be no Reflection; and consequently from thence no Impression; and being no Impression, but *Triangular*, there can be no other *Figure* represented to the Eye.

C H A P. XXVI.

Refraction is the carrying of the Solar Rays from a Right Line to a Crooked, as they pass from a Rare Medium to a Dense, and from a Dense to a Rare one again.

The

The Solar Rays being Body (as has bin shew'd before) must find fit Meatus or Pores in the several Bodies thro' which they pass; but because we find in that Glafs Parallelogram $A B C D$ that those Rays that fall upon it Perpendicular to $A B$, find Perpendicular Pores for their Passage, as



as $h v$ and $f p$; and those that fall Obliquely upon any part of the Glafs, find Oblique Pores thro' which they pass, with a little Variation: as the Ray $e n$ finds a Passage towards m , but with some little Variation, being Refracted to p : and the Ray $g o$, has an Oblique passage towards q , but in it is refracted to r , and from thence to v : and if you turn up any other side of the Glafs, it will always be the same. Hence it appears, that Glafs and all perspicuous Bodies must have Direct Pores thro' them all manner of ways, to give Passage to the Rays Reflected from all sorts of Objects in all Places and Positions.

Now for the better understanding of this, 'tis proper to enquire what sort of a Body this must be, and of what sort of Particles it must consist, to be thus modified. And because we find that all Fluid Bodies (that have not their Pores repleat with alien Particles) are Perspicuous, as Ether, Air, Water, Spirit, &c. we may conclude that the same sort of Particles are conduc-

Q

ing

cing to Fluidity, and Perspicuity. And because *Æther, Air, Water, Spirit*, are First Principles, they must consist of *Homogenous Particles*, of such a Figure, as is most proper for Fluidity, they being most Fluid; which seems to be Globular, because Globular Particles standing upon a Point, the least Addition on any side of them alters the *Equilibrium*, and makes them roll off; and for this Reason they cannot lie one upon another, but if cast upon a Plain they spread or thrust one another to a great distance from the Centre, or from the place where they were let fall: as we see Childrens Marbles do, if thrown upon a Floor.

So that to make a Body Fluid, two things seem to be necessary, *viz.* Globular Particles and some intervening Matter, that may hinder them from touching each other, any otherwise than as Childrens Marbles do, the Air or some more subtle Body still intervening, which still keeps all Fluid Bodies composed of Globular Particles (as suppose Water) in Motion, or ready to separate: for the Pressure of the Atmosphere is always varying, and therefore the Spring of those Aerial Particles that are in the Pores of Water will expand it self, when the Gravity of the Atmosphere is lesser, and Force the Water Particles to a greater Distance; which again Contract, when the Gravity of the Atmosphere is greater, and therefore suffer the Water Particles to lie closer. So that by the dilating and contracting of the Aerial Particles in the Water, and the Gravity of the Atmosphere Varies, it seems to be in a Constant Agitation.

This Notion the Honourable R. Boyle makes out by many Experiments, where he treats of *Fluidity*.

But if Watry or Globular Particles should touch so that nothing should intervene, the Pressure of the Atmosphere being equal to the Pressure of a Pillar of *Mercury* of the same bigness of 30 *Inches* long, would keep them so together, that nothing but a Force equal, or exceeding that Pressure could separate them.

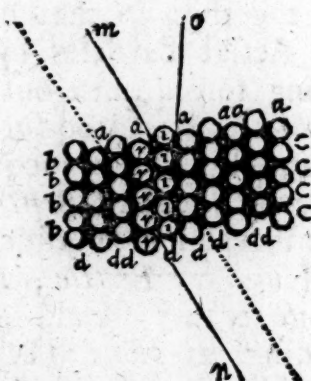
And this I take to be the Case of Glass, which was in a state of Fluidity when the subtle Fiery Particles divided it into Globules and kept them asunder. But as those Fiery Particles receded, these closed together, so that nothing could intercept, the Aerial Particles by the Activity of the Fire being forced quite out from them, and the Fiery Particles being too subtle to stay there and being thus closed, they acquire that Degree of Firmness which we call *Brittleness*.

There are indeed some Perspicuous Bodies that are neither *Fluid* nor *Brittle*; as this *Hypothesis* seems to intimate they should be, but are *Fleddible* and Yielding, as *Horn*, *Isinglass*, &c. Tho' I must grant that these, as they are Perspicuous must consist of Globular Particles; yet I conceive they may be joined or twisted together, like a Thred turned into the Figure of 8, which being Soft and Yielding may be Bended backwards and forward, this way or that; this sort of Figure being very apt for that purpose; and this may fairly be supposed of *Horn*; which is gradually increased, and composed of *Animal Fibres*; and indeed their Figures being so easily untwisted and destroyed by Fire, may argue them all to be of this Nature.

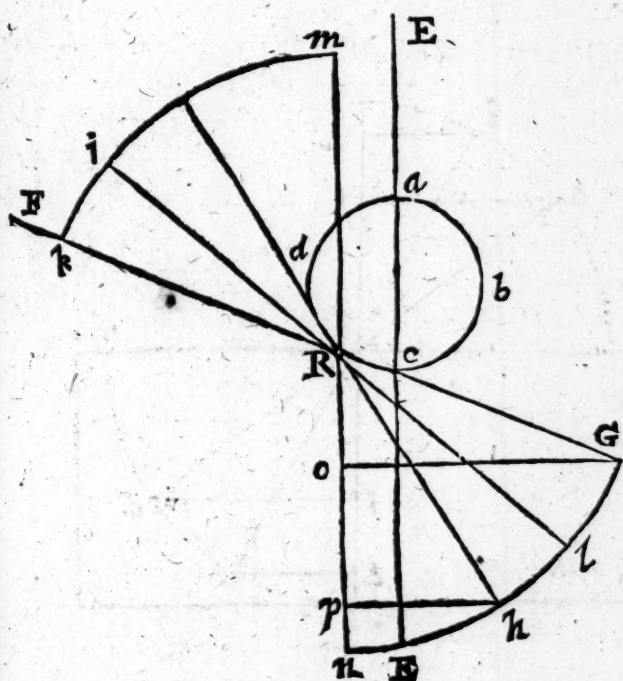
Concluding from these Observations, that the Particles of Perspicuous Bodies are Globular; for my better Satisfaction, I form'd the following *Fig.* of Globular Particles, intending thereby to imitate a

Glass Parallelogram, to try whether they would produce a Body that would give me some farther Light into the Nature of *Perspicuity*: and according to my Expectation, I find it a Body every way fit for my Purpose, furnished with Direct Pores, all manner of Ways, as $a d$, $a c$, $a b$, $b d$, $d c$.

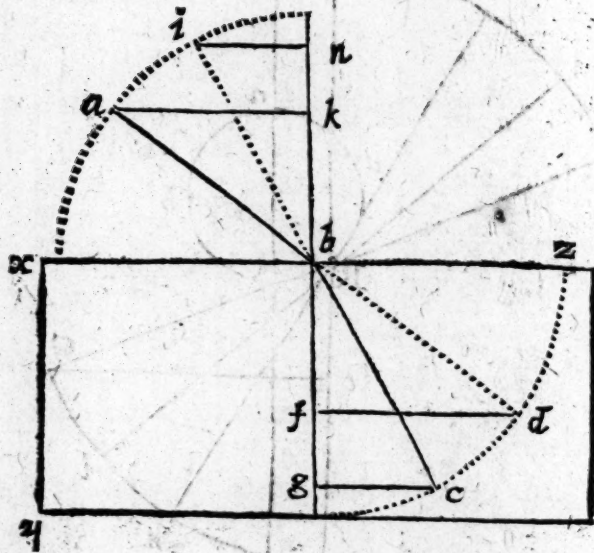
Now supposing Glass, and all Perspicuous Bodies, to be composed of Globular Particles, and



furnished with Pores like this *Fig.* and the *Solar Rays* to be Bodies (as has bin proved) so *Elastic* and Darted from the *Sun* with so much Force that the Angle of Reflexion is equal to the Angle of Incidence, it will follow that the *Solar Particles* falling upon Globular Bodies, that are hard, smooth, and apt for the purpose, will be Reflected in an Angle equal to the Obliquity of the Tangent at that part of the Curve they fall upon as suppose in the following *Fig. a b c d*, to be a Globular Body or Particle of Glass, $E E$ a Perpendicular Ray, f an Oblique Ray falling upon the Tangent at r , where 'tis Reflected from its Right Course to g , and turns to b , and makes the Angle $b r l$ equal to $i r k$; but the Globule $a b$



being too big, we will consider it as a Point, and suppose the Ray $m n$ to be the Perpendicular, and then the Sines of the Angle of Incidence $k r m$ equal to $g r n$, will be equal to 300, and the Sine of the Refracted Angle $b r n = 193$, and the Sine of the Angle of Refraction $g r b = 107$, which is the exact way that the Solar Rays pass from Air thro' Glass, as Mr. *Molyneux* in his *Dioptrica Nova*, or *Treatise of Dioptrics*, observes, and demonstrates; As in *Fig.* following, which is His 5th. Tab. 1st, 'Where He says, $z x y$ is a Body of Glass, $b b g$ is Perpendicular to $z x$, $a b$ is a Ray falling on this Glass, and the Angle of Inclination or Incidence is $b b a = d b g$. Kepler tells us, that under 30 Degrees of Inclination from Air to Glass, the Angle of Refraction $d b c$ is $\frac{1}{3}$ of the Inclination, therefore the Refracted Angle $c b g$, is $\frac{2}{3}$ of the Inclination, 'where-



wherefore we lay down the following Proportions, as confirmed by *Kepler's Experiments*, and usually retained by most *Optic Writers*.

- < *Inclination* d b g : *Refracted Angle* c b g :: 3 : 2
- < *Inclination* d b g : < *Refraction* d b c :: 3 : 1
- < *Refraction* d b c : *Refracted Angle* :: 1 : 2

But suppose the Ray *c b*, to proceed from *Glass* to *Air*, at *b*, 'tis *Refracted* from the Perpendicular *b h*, and becomes *b a*, here the *Inclination* is *c b g = h b i*, and then,

- < *Incidence* h b i : *Refracted* < h b a :: 2 : 3
- < *Inclination* h b i : < *Refraction* i b a :: 2 : 1
- < *Refraction* i b a : *Refracted* < h b a :: 1 : 3

But

But the Learned and Ingenious Mr. *Isaac Newton* of Cambridge discovered by most accurate Experiments; that these Proportions of *Kepler* were not sufficiently exact, for *Des Cartes* found that Refractions were not to be measured by the Proportion of Angles, but by the Proportion of Sines, *Vid. His Dioptrics Chap. 2. Sect. 7.* And therefore Mr. *Newton* applied himself to discover the Proportion of Sines, and found that from Air to Glass the Sine $a k$ or $d f$, of the Angle of Incidence $a b k$ or $d b g$, is to the Sine $i b$ or $c g$, of the Refracted Angle $c b g$ or $i b h$:: 300 : 193 (or near as 14 to 9.) And on the contrary that from Glass to Air, the Sine of Incidence, is to the Sine of the Refracted :: 193 : 300, or as 9 to 14; which He has established, and is received as the nearest Proportion, by all *Optic Writers*.

Now suppose in the same Figure, a to be an Elastic Solar Particle, falling inclined at b , upon a Globular Particle of Glass, hard, smooth and apt to Reflect it; which Globular Particle, tho' it has Dimensions, and is abundantly bigger than the Solar Particle, is yet so little as to escape our Sight, and consequently to us must appear as a Point.

2dly, The Solar Particle being Elastic, and falling upon a Globule hard, smooth, &c. must be Reflected.

3dly, Because in Glass it meets with Pores every way for its Passage; and the Angle of Reflexion is equal to the Angle of Incidence, it must be Reflected in Proportion to the Obliquity or Inclination of the Tangent of the Curve in that part it falls upon; and if it falls in an Equal Obliquity to that at r , in the Figure p. 229. it will be Reflected in an Equal Degree, and make equal Sines,

and Angles with it, which being in a *Dense Medium*, we call *Refraction*.

And, 4^{thly}, In this it differs from that in *Air*, that 'tis longer in passing thro' *Glass* than *Air*; I conceive the reason is, because the *Particles* in *Air* being Fluid and Yielding, give way to the *Solar Rays* to pass in *Right Lines* thro' it, but the *Particles* in *Glass* being Hard and Fixt, the *Solar Rays* are Reflected backward and forwards from *Particle* to *Particle*: Thus ~ as in Fig. p. 228. suppose *m*, a Ray of Light falling upon the Glass Globule *i*, thence to *r* again, and so quite thro', and therefore it must be longer in passing thro' it, than thro' *Air*, where their way is in, or near a Right Line.

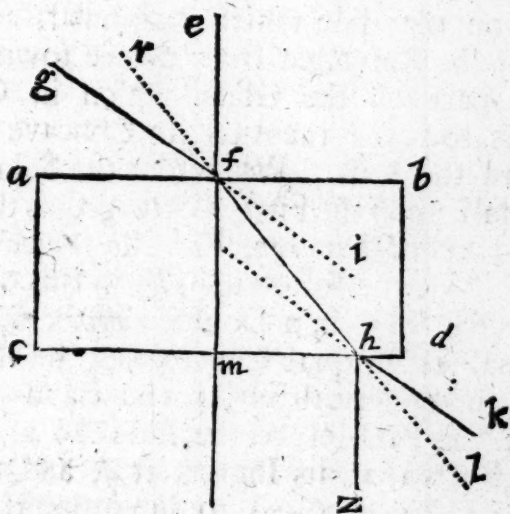
5^{thly}, This may be the Reason why the Solar Particles are more Refracted in Glass than in Water, and in Water than in Air; because the Particles in Glass being hard and fixt, make the Angle of Reflexion equal to the Angle of Incidence; but the Particles in Water, being Fluid, and in Motion, by yielding to the stroak of the Solar Particle, cause a less Resistance, and therefore a more obtuse Angle of Reflexion. The Particles in Air being more Fluid, Light and Yielding, than Water, make so small a Resistance, that they scarce drive them from a Right Line, except loaded with Vapours or Exhalations.

Now if this be the way that a Ray of Light passes thro' Glass, &c. it will follow, 1st, That when the Glass is of an equal thickness, if the Ray falls Obliquely upon it, and Reflected or Refracted from that side of the Glass Globule, that is farthest from the Axis where it Immersed, it will fall upon, and be Reflected, from that side of the Globule that is next to the Axis, where it Emerges, & *e contra*, as in Fig. p. 228.

Suppose

Suppose m , a Ray of Light falling Inclined upon that side of the Globular Particle of Glass that is farthest from the Axis o , from whence 'tis Refracted or Reflected to the contrary side of the Globule r , and so on; 'tis manifest that if there be an equal number of Particles on both sides, if it fall on that side the Globule i , that is farthest from the Axis o , or middle Perpendicular Ray, where it Immerges, and 'twill fall on that side the Globule r , that is next the Axis or middle Perpendicular Ray, where it Emerges, from whence 'twill be Reflected, or if you had rather Refracted to n , and make a Parallel Line to m : which is the way that the Writers in *Dioptrics* observe it to pass.

As in following Fig. which is *Molyneux's Fig.* where He says, ' $g f$ is a Ray of Light, falling inclined on the Glass $a b c d$, this Ray coming



out of a Rare Medium as Air, into a Dense Medium as Glass, does not proceed on its direct Course

Course in a Strait Line towards i , but at the Point of Incidence f , 'tis Bent or Refracted towards its Perpendicular $f m$, and becomes the Refracted Ray $f h$.

At b is the Point of Incidence again from Glass a Dense Medium, to Air a Rare Medium, and in this Passage 'tis Refracted from the Perpendicular $b z$; so that instead of proceeding directly straight in $f h l$, 'tis Refracted from the Perpendicular $b z$, and becomes $b k$: so that if the Surface $a b$ be Parallel to the Surface $d c$, the Ray becomes again, as if it had not bin Refracted, for now $b k$, runs Parallel to $g f$.

2dly, 'Twill follow that if a Ray falls upon a Convex Glass Parallel to the Axis, it will be doubly Refracted towards the Axis: first in Proportion to the Obliquity or Inclination of the Tangent, wherein it Immerses; 2dly, in the same Proportion, where it Emerges. For where the Glass is of different Thickness, 'twill come to Air first on that side which is thinnest, and consequently be Refracted from thence towards the thickest part of the Glass, which in Convex Glasses is towards the Axis, in Concave Glasses fromward the Axis. Wherefore the Solar Rays as they fall upon the First, Converge, as they fall upon the Second Diverge, Vid Molyneux's: Tab. 7. Fig. 1. Or the following Fig. in this.

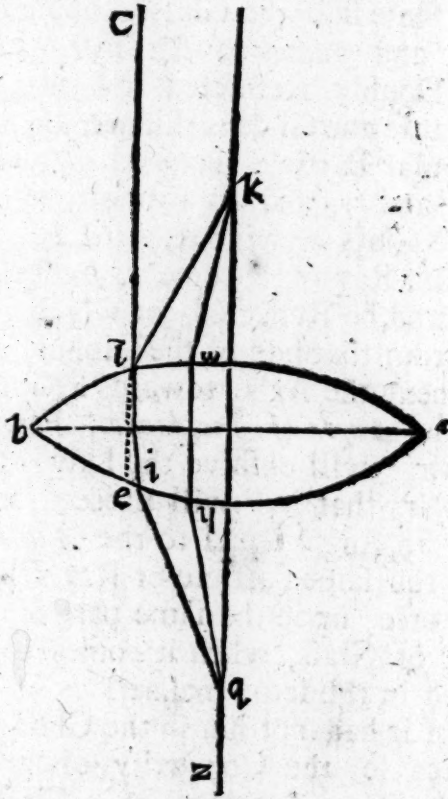
Where He says, in a Double Convex Glass $a b$, of equal or unequal Convexities, let the Centres of the Spherical Surfaces be k and q , $c d a$ Ray falling Parallel to the Axis $k q z$, and being Refracted at its Ingress at d , and at its Egress at i , 'tis required to determine the Point of its Concourse with the Axis at z , &c.

Here

Here 'tis plain, that tho' the Ray $c d$, falls on that side the Globular Particle of Glass d , where it Immerses, that is next to the Axis; yet it will fall on the same side the Glass Globule e , where it Emerges, and comes to Air first, and consequently be Doubly Refracted towards the Axis $k q z$; because the Glass is thinner, or consists of fewer Globular Particles betwixt d and e , than betwixt w and y , and so Proportionably in all Parts of the Glass betwixt w, y and b ; and therefore the Solar Ray must come to Air first at the Globule e , and be Reflected, or which is all one, Refracted from that side of the Globule e , that it falls upon next the Axis, towards z , in an Angle equal to the *Angle of Incidence*. For when it comes to Air, 'twill observe the Law of Reflexion in the Air, that is, 'twill proceed in a Line, that makes an Angle equal to the *Angle of Incidence*; for the same Particle or Ray falling with the same Force, upon the same part of a Globular Particle of Glass, when it comes to Air will be Reflected in the same manner, as in the open Air, or as if it had not bin in the Glass at all.

3dly, Because the Convexity of a *Lens* or Burning Glass is a Segment of a Circle, therefore the Obliquity, or Inclination from the Axis will encrease uniformly, and consequently the Solar Rays falling upon the Glass, will make the Angle of Refraction $k r q$, more or less Acute, as they fall nearer to, or farther from the Axis of the Glass. Those that fall near the Axis, making an Angle more Obtuse, the Inclination of the Tangent there being less; Those that fall farther off more Acute, as $k d q$, because the Inclination is there greater. For which reason they will all cross the Axis (after they have bin twice Reflected, near the same place; which we call the

the *Focus*, or *Point of Convergency*, or *Concourse*.
But those Rays that fall nighest the Axis will



cross at the greatest distance ; because those that fall nighest to it differ very little from Parallel Lines with it upon a Plain, the Inclination of one Point in a Circle to the next to it, being the least imaginable, and consequently the Rays there falling must have the least Refraction imaginable, *Vid. Motyneux's, Tab. 8. Fig. 1, 2, 3.* in each of which He says, ' The Radius of Convexity *c v*, is two Inches, or 20000 Parts, an Inch being 10000 Parts, the Arch $\overset{\frown}{r} \overset{\frown}{o} r$, in the first and second Figures is a Quadrant, and consequently

quently the Thickness of the Glass $u z$, in each is 5858, being the *Versed Sine* of 45 to the Radius 20000, but in the *Double Convex* Fig. 3. the Thickness of the Glass is $\frac{2}{3}$ of an Inch, or 8000 such Parts.

$a b$ in each is a Ray falling upon the Glass Parallel to the Axis $c r$, at the Distance of $\frac{1}{15}$ of an Inch, or 1000 such Parts as $c r$ is 20000, $d e$ a like Ray falling one half or $\frac{1}{2}$ of an Inch, or 5000 such Parts distant from the Axis, i is the Point wherein the Ray $a b$ meets the Axis, h the Point in which $d e$ crosses the Axis here $a b$, the Ray that falls nighest the Axis $c r$, crosses it at a greater Distance (*viz.*) at i , than the Ray $d e$, which falls upon the Glass farther from the Axis, crossing it at h , which makes that which they call the *Depth of the Focus* $h i$.

The same Hypothesis will solve the Cause of any other *Phenomenon* in Refraction; but I fear you will think I have bin already to long, wherefore I shall only add (if it be required,) Why Rays Parallel to the Axis of the Glass, always fall upon that side of the Glass Globule, that is next the Axis of the Glass; and Oblique or Inclined Rays, always fall upon that side of the Glass Globule, that is farthest from the Axis of the Glass Body. I answer, all Rays being Darted from a Globule or Convex Body, *viz.* the Sun must Diverge, as we see all Rays Reflected from a Convex *Speculum* do; and therefore properly speaking, there can be no parallel Rays; but those are called Parallel, that seem so to sense, as (in fig. 3. tab. 8. of *Malyneux's*) wherefore if Rays Diverging from the Axis at c , of the Glass Body towards b or e , fall so as to pass thro'

thro' the Glass, they must fall on that side of the Glass Globule that is next the Axis of the *Lens*; the Body of the Glass Globule hindering, or shading them from the other side: and Oblique Rays must fall on that side the Glass Globule, that is farthest from the Axis of the Glass, for the same reason.

As in *fig. pag. 230*. 'tis plain that if the Ray *ab*, did not fall upon the inside of the Glass Globule *b*, or that side that is farthest from the Axis *kg*, it would not pass thro', but be Reflected above the Surface *xz*; because one part of a Globular Body always shades the other. And that all Rays do Diverge, observation has already taken notice of: For Mr. *Molyneux* says *pag. 3d*. 'Parallel Rays are those that flowing from one and the same Point of a remote Object, pass at the same Distance as to Sense; but this is not to be strictly taken, for then the Rays following from one and the same Point of an Object, cannot be Parallel, for they always Diverge; yet when an Object is at so great a distance, and that Parcel of Rays, which is considered is so small, that their Divergence is little, or nothing considerable, those Rays are said to be Parallel; *Tab. 1st fig. 4th*. *a*, is a Point in an Object, sending forth its Diverging Rays *ad*, *ab*, *ac*, *ae*, let *bc* be the Breadth of the Pupil, or Breadth of an Optick Glass; here if the Point *a*, be so remote, and *bc* be so small, that the Parcel of Rays *bac*, do insensibly run Parallel, then these are said to be Parallel Rays.

Since

Since I wrote what you have already read, I have had an Opportunity to see that Demonstration of indefatigable Industry, I mean the Great *Newton's* late Book of Opticks and Colours, in which I find what I had from Mr *Perk's* not only confirmed by the same, but Illustrated with many more Nice and Curious Experiments; by which the Doctrine is so vividly represented, and so curiously answers all the *Phænomena of Colours*, that I cannot without a Reluctancy dissent from it.

But there is an Error in the Foundation, which will at least weaken, if not decay the Whole Superstructure. For if it does appear that all the Experiments that he has there made, are made with Light, whose Rays have different *Angles of Incidence*, all that he has there said proves nothing; for if the *Angle of Refraction* bears a Proportion, (or if the *Angle of Reflexion* after it Emerges, be equal) to the *Angle of Incidence*; it will not follow, if there be different *Angles of Incidence*, that those Rays that are most *Refracted*, are most *Refrangible*. To shew which, I shall only exhibit one Figure, which I think will plainly detect that oversight of his, and at the same time confirm my own *Hypothesis*; and not stay to consider every Experiment Page by Page, which would be too long for such a Tract as this.

Let

Let *A* be the Sun, *b*, *d*, *f*, three Pencils of Rays proceeding from three several Parts of the Sun's Body, falling upon the several parts of *g* a *Prism*, consisting of Globular Particles or Corpuscles, and from them Reflected where they Immerge, from Corpuscle to Corpuscle, in Angles equal to the Angle of Incidence, the nighest way they can thro' the Pores, till they came to Air, and then in a Line Parallel to the Line of Incidence, and consequently equal to the same. Of which, those Rays that proceed from *b*, make the most Acute Angle, where they fall upon the *Prism*, and are therefore most Refracted after they Emerge, viz. to *x*; those at *f*, make the most Obtuse Angle, and therefore are least Refracted, viz. to *z*; those at *d*, being in a Mean are Refracted in the intermediate Spaces. Those Particles that flow from the Centre of the Sun at *m*, falling Perpendicular, will in great measure be scattered by the Dead Edges, and those that are not, will be too oblique to enter the Pores; but instead of that, will be Reflected in Parallel Lines, from the upper part of the Globular Corpuscles in the Surface of the Glass in great Numbers, because the Bodies of the Globules are bigger than the Pores; and because they fall in great Numbers, and Parallel Lines from the Sun they will make that Lucid Spot at *q*. And because the Rays at *b*, are very Oblique, they cannot so numerously enter the Pores of the *Prism*, as those at *d*, but many of them will be reflected from the upper parts of the Globular Particles to *k*, by which the number that pervade the Pores of the Glass will be lessened, and therefore the Colour that results from them darkned.

R

Now

Now observe that those Rays, that from the Centre of the Sun at *m*, proceed to the Earth in a Perpendicular Line, are not at all Refracted, as they pass thro' the various Mediums betwixt the Sun and it, and those Rays that proceed Inclines nearest the Perpendicular, as from *b*, have the least Refraction; those that proceed from remoter parts of the Sun, as from *d* and *f*, pass in a more Oblique Line to the Earth, and consequently suffer greater Refractions in their Passage. So that tho' those Particles that are sent from the same Radiating Point, diverge so far, that they would never come near the Earth or Centre, if they proceeded in a right Line, as the Ray *i*, would to *o*: yet by the various Refractions that it continually suffers from a perpetually Denser Medium, it is turned about to the most distant Pore in the Glass, or remotest part of the Earth. So that as the Rays that are sent from various parts of the Sun, as from *b*, *d*, *f*, *m*, have various *Angles of Incidence*, so they suffer various Refractions, and therefore in every of those Points are differently crost and mixt among themselves, and fall upon the Globular Particles of the Glass in different Angles, and have different Tangents, as they thus crost and mixt; and are differently Reflected from the Globular Particles where they Immerge and consequently make a different Alteration in the Organ of Sight, or different Colours: Of which those will seem the Lightest, where the Rays pervade the Glass in greatest Numbers, which will be from the middle of the Glass, that part being evidently exposed to those Cones, and where their Rays are least dispersed, or absorbed by the dead Edges; so that they will be *Blue* at *x*, *Green*, *Yellow*, &c. at *y*, and *Red* at *z*.

If the *Blue* Rays have a different Angle of Incidence from the *Yellow*, and the *Yellow* from the *Red*, &c. if you turn the *Prism* upon its own Axis, so that the *Blue* may appear at *x*, the *Yellow* at *x*, and the *Red* at *y*, the Angles of Incidence in each of them will still be as different as they were before, and consequently the Colours will appear in as distant places.

2dly, If the *Blue* be transmitted to another *Prism*, as in the first Experiment, that I had from Mr. *Perk's*, and in Mr. *Newton's* Opticks Experiment, sixth Illustrated by Fig. 18, if that second *Prism* makes no Alteration in those Rays, they will appear in the same Angle still, and then if the *Prism* be turned so, that the *Red* or *Yellow*, be transmitted in the same Line, to the same part of the other *Prism*, if that other *Prism* makes no alteration in the *Red*, *Yellow*, &c. they will be seen in the same different Angles, or distant Places Still. But if that other *Prism* makes an alteration in the *Blue*, it will make a Proportional alteration in the *Red* too, &c. and therefore they will always appear in the same Angles, and at the same distance; because equal Things added to, or subtracted from equal Things, will give equal Sums, or Remainders.

3dly, If you turn the *Prism*, so far from its own Axis, as to make it touch *f*, the Pores in the Surface of the Glass, will be so Oblique to that Pencil of Rays at *b*, that they cannot enter them, but will be Reflected to *k*, and consequently the *Blue* must totally disappear, the *Red* and *Yellow* remaining; because they proceeding from a different Angle of Incidence, have yet Power to enter those Pores, (which answers Mr. *Newton's* Query Page 66. Book 2d.) And so long as they have Power to enter those Pores,

they will do it in the same manner, that they fall upon the Globules where they Immerge, which will be in the same manner that they proceeded from *d.* or *f.*, and consequently will cause the same Sensation or Colour. If you turn it farther upon its Axis, as to touch *r.* or *n.*, they will all disappear one after the other, for the same reason; and therefore as the Pores in the *Prism*, as 'tis turned upon its own Axis, become so oblique to the Rays *b, d, f.*, that they cannot Immerge, so they have *Fits of Easy Reflexion*, (i. e. are Reflected from the upper Hemisphere of the Globular Particles, in the Surface of the *Prism* :) but as they come so direct that they can easily pass thro' them, so they have *Fits of Easy Transmission*, as He calls it, in His *Opticks* Book 2d. Pag. 81. Tho' I must acknowledge, He gives a different Cause of this *Phænomenon*, in the foregoing Page, tho' not so satisfactory at least to me.

Those *Fits of Easy Transmission*, are of two Sorts, either as the Rays that are Transmitted, do afterwards appear Coloured or Lucid.

Those Rayes that are Transmitted thro' a *Prism*, when 'tis in such a Position to the Sun, as in the Figure, the *Prism g.* is to A, will appear Coloured at *x, y, z.*

Those Rays that are Transmitted thro' a *Prism*, when 'tis in such a Position to the Object, as the *Prism g.* is to C, because they proceed in Parallel Lines to Pores that are Direct, which they therefore pass without any considerable Refraction, They (or the Object) will appear the same, thro' the Glass to the Eye at E, as they would to the naked Sight.

Those Rays that are Transmitted thro' the *Prism*, when 'tis in such a Position to the Object, as the *Prism g.* is to B, will Converge as they

they pass thro' the Pores, and consequently be collected into a Point, and therefore appear Lucid to the Eye at D or E; and this is the Cause, why those Rays that appear coloured at x, y, z , as in the Second Experiment, I had from Mr. *Perks*, appear Lucid in a round Spot to the Eye at F.

From which Fits or Disappearance of Colours, He argues in a Parallel Case, in his *Opticks, Exp. 101b. Illustrated by Fig. 22. Pag. 401b.* thus, The Light therefore which Emerged out of the two *Prisms*, is compounded of Rays differently Refrangible, seeing the more Refrangible Rays may be taken out of it, while the less Refrangible remain. But this proceeds purely from the Obliquity of the Pores, and therefore the inference has no Force.

4thly, If the Rays that appear in the Colours at x, y, z , be produced to the Lens $\alpha \beta$, in the same manner that they fall upon it, they will be Refracted by it: If they fall upon it in great Numbers and Parallel Lines, they will always appear Luminous, as they proceed from it; but more Lucid and Glaring as they are collected into less Space, or drawing nearer to the *Focus*: If they fall upon it scattered, crost, and confus'd, each Ray being Refracted, in a Proportion to its Angle of Incidence, and consequently the Rays x, y, z , will appear in the same scattered, and confused manner near the Lens after they have past it, as they did before, or when they fell upon it; and therefore cause the same Sensation before and after; but as they proceed farther, so they will be collected into less Space, and their crossing will be less discernible, and therefore they will appear Lighter till they come to the *Focus*, where they will be so numetous, and collected so clos, as to Affect the Eye

with violence, and not to be distinguished from Parallel Lines, and therefore appear Lucid: If they pass on farther beyond the *Focus*, they proceeding in right Lines, will again separate and Diverge, and as they proceed farther, so they will appear in the same scattered manner as they did at the *Lens*, the Rays at Δ being the same that appeared *Blue* upon the *Lens* at β , only produced to the Paper $y\omega$ to Δ , and the *Red* Rays at α , the very same produced to ω .

But if the *Prism* $\gamma\iota\kappa$ be so placed as to Reflect the Rays, exactly as they are closely collected and united in the *Focus*, or transmitted, as from α, γ, δ to F , or from B to D , they will be Reflected, closely Collected and United in the Pillar $\gamma\lambda$, because they are Reflected in the same manner that they fell upon the Glass: But if that Pillar fall upon the *Prism* $klmo$, its Rays will again be scattered by it, and appear in Colours upon the Paper ev ; at $vqrst$.

Now if you intercept any Colour, (as in His *Prop. 16. Prob. 6. Pag. 141. Illustrated by Fig. 16.*) at the *Lens*, suppose at β , they will be intercepted at Δ , because they are the very same Rays produced; or if they are Reflected by the *Prisms* $\gamma\iota\kappa$, and intercepted at β , they will disappear at v , upon the Paper ev , because they are the same Rays that appeared *Blue* at β produced: For the same Rays that fell upon the *Prism* $\gamma\iota\kappa$ in the *Focus* are Reflected or Transmitted from thence in the very same Angles that they fell upon the Glass, and are the same continued, to $vqrst$. So that that Lucid Pillar $\gamma\lambda$, is not a new Light, compounded of the several coloured Rays, as he intimates, in the above mentioned *Proposition* or *Problem*, but the very same Light that was sent from the several Parts of the

Sun's

Sun's Body b, d, f , &c. and is continued in the very same Angles, and Refractions to the Paper $e v$. For in the same manner, and in the same Angles that it fell upon the Globular Particles of the *Prism g*, 'tis Reflected from them to x, y, z , because the Angle of Reflexion is equal to the Angle of Incidence, and in the same manner that it proceeds from x, y, z , it falls upon the *Lens* $\alpha \beta$; and in the same manner, and in the same Angles that it falls upon the *Lens* $\alpha \beta$, it is Refracted by it to the *Focus*, when it falls upon the *Prism* $\gamma \lambda$, in the very same Angles, and crost in the very same manner that it fell upon the *Lens*. Which is evident by their appearance in the very same Lines and Colours $\delta, \zeta, \eta, \theta$, upon the Paper $y u$, if suffered to proceed, and therefore they have the very same Angles, &c. when they fall upon the *Prism* $\gamma \lambda$ in the Point of *Convergency*, and consequently will be Reflected from thence, in the same manner, but closely collected and united in the Lucid Pillar, as they fell upon the Glass; and consequently will be the very same Light, with all the same Qualifications, that fell upon the first *Prism g*. And therefore all things that may be expected from that, may likewise be expected from this; as first, when it falls upon the *Prism k l m o*, that it should be Refracted by it upon the Paper $e v$, in the same Colours $v q r s t$, that it was by the first *Prism g* at $x y z$, &c. Secondly, If any Body be placed in this Beam of Light $\gamma \lambda$, 'twill appear of the same Colour as it would in the Light of the Sun, where it falls upon the *Prism g*; because the same Causes have the same Effects upon the same Bodies. So *Vermillion* would appear *Red*, *Grass* *Green*, &c. But if the other Colours are intercepted, and the

Red Rays at *b*, or *y* only, are suffered to proceed, the Red Colour of the *Vermillion* will be advanced; because those Particles only fall upon them, that proceed from such an Angle of Incidence that the Corpuscles in their Surface, by a peculiar Modification are most appropriated to Reflect. But if any other are mixt with them, that proceed from a different Angle, they will have different Tangents upon those Corpuscles; and consequently be Reflected from them in a different manner, which will Strain, or in some Measure alter their Colour. If the Red Rays at *b* or *y*, are totally intercepted, those Rays that proceed from other Angles, and are otherwise mixt, and crost among themselves, having different *Tangents* upon those Corpuscles, cannot be Reflected in the same Angle that the Red were, nor consequently cause the same Alteration in the Eye or Phantasie, of the same Colour that the Red did.

5thly, If the *Red, Green, Yellow*, and all their intermediate Colours are intercepted at *y, z*, and the Blue only are suffered to fall upon the Lens *a, b*; the Blue will want all these Rays contained in the intercepted Colours, to make them appear Luminous, or to be the same they were when they fell upon the Glass *g*, collected by the Atmosphere, and other Mediums in their Passage betwixt the Sun and it: and therefore the Rays remaining in the Blue, will be so few, so scattered, and will fall in such an Oblique Figure upon the Lens, that they cannot be sufficiently collected, by an ordinary Glass, to appear at all Luminous. But I have collected them so, by a Lens of $\frac{1}{4}$ of an Inch thick and $2\frac{1}{2}$ Inches Diameter, as to make them appear Lucid, tho' in a Point no bigger than a Fin's Head.

This

This shews, that the Reason why a Single Colour is not easily altered by Refraction, is not because all its Rays are of one Homogenous Colour, as Red, Blue, &c. but because they are so few, and so dispers'd that they cannot be collected in the Point of Convergency, in a number sufficient to affect the Eye with so much Violence, as to appear Luminous.

6thly, If you look upon the Colours $qrst$, on the Paper ev , or upon them at st , upon the Paper yw , &c. thro' a Prism in any Line different from that they proceed in to those Papers, as suppose at q or r , they will appear to the Eye thro' it, in the same manner as they would to the naked Eye. For in the same manner and Angles that they are transmitted from the Paper to the Eye, they are transmitted from the Paper to the Glass, and in the same Angles, and Lines that they fall upon the Glass, they are transmitted by it to the Eye, because the Angle of Reflexion after Emergence, is equal to the Angle of Incidence, as well as before; and therefore they will appear in the same Places and Colours thro' it, as they did to the naked Eye. If you intercept the Colours at $qrst$, the Blue will appear single at v ; if you intercept the Colours $vqrst$, the Red will appear single at r . For if they are seen altogether in the same Place thro' the Prism, as they are to the Naked Eye, they will be seen each in particular in the same place thro' the Prism, as they are to the naked Eye, for the same reason.

7thly, If you make a Hole thro' a Black Paper, as in his 12th Exper. Book 1. Pag. 52. and let part of the Blue or Red Rays thro' it; it will appear in a Red or Blue Spot, of the same Figure as the Hole, whether Round or otherwise.

8thly,

31bly, If in the Red or Blue Light, &c. which he calls *Homogeneous*, you place a Circle of $\frac{1}{2}$ of an Inch Diameter, as in his *Exper. 13. ibid.* and in the Sun's unrefracted White Light, which he calls *Heterogeneous*, you place another of the same bigness, and go from the Papers to the distance of some Feet, and view both Circles thro' a Prism, the Circle Illuminated by the Sun's *Heterogeneous Light*, will appear very Oblong, as in the 4th Experiment, the Length being many times greater than the Breadth: but the other Circle Illuminated with *Homogeneous Light*, will appear Circular, and distinctly defined, as when 'tis viewed with the naked Eye. The reason is, because the Rays in the Red or Blue Lights, are already as much scattered and dispers'd as they can be by the *Prism*, and therefore appear the same to the naked Eye, as thro' the Prism, without any farther Alteration: but the Simple or White Light of the Sun being collected by the Atmosphere, &c. is capable of being scattered and dispers'd into that Oblong Figure of various Colours by the *Prism*. Which likewise shews the Cause of the different appearance of Objects in his 14th Experiment, *ibid.*

Thus I have (I think) fairly and naturally Accounted for all the *Phænomena* of *Light and Colours*, in the chief Experiments in Mr. Newton's Book of *Opticks and Colours*: to which all the rest may be easily reduced, and yet admit all the *Solar Particles* to have the same Operation upon all Bodies, and to be purely *Homogeneous* in Colour, *Refrangibility*, and all other respects among themselves; and have shewed that the true Cause of Colour, is the different Alteration that they make in the Organ of Sight, as they proceed from different Angles, in a different Manner and Number to the Eye.

I shall next shew, 1st, That all the *Experiments* that Mr. *Newton* has there made, are made with *Light* whose *Rays* have different *Angles of Incidence*. 2^d, That all the *Rays of Light*, in all Colours have the same Degree of *Refrangibility*. 3^{dly}, That the several *Rays of Light* are not of several Colours in themselves.

First, If there are *Rays* that proceed from the several Parts of the Sun, as in the *Figure* from *b, d, f*, and are from each of those Parts transmitted to every particular Pore in the *Prism g*; it will follow, that not only that *Light*, that falls upon the *Prism* in general, but the *Rays* that pass thro' each Pore in particular, have different *Angles of Incidence*; because they proceed from distant Points. And that there are *Rays*, that do thus proceed from those Points, is evident, or else that great Supposition in *Optics*, is false, that from every *Physical Point of an Object*, *Rays of Light* are diffused in *Direct Lines*, thro' all the *Hemisphere* round; as in *Molyneux's Dioptrics Tab. 2d. Fig. 2d.* is explained, and seems very agreeable to Truth: Because the whole entire Image of the Sun, may be seen in all places of the Earth's Hemisphere, that is expose to it at the same time: Now if there was not *Rays of Light* sent from every Part of the Sun to all those Places, 'tis impossible that every Part of the Sun should make an Impression on the Eye, or be seen in those Places.

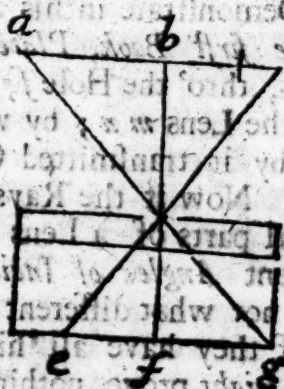
2^{dly}, If all the Sun's *Light* that fall upon a more Dens Diaphanous Convex Medium, will be so Refracted by it, as to Converge towards a Focus, those more Diverging *Rays* that are sent from each Point *b, d, f*, will be Refracted by the Denser Atmosphere of the Earth, when they fall upon it, and proceed to the Earth, as collected thereby

thereby into a *Focus*; by which, there will yet seem a greater difference in the *Angle of Incidence*, the Refracted Ray making one Side of that Angle, which will then have an Angle of Incidence, not as the Ray *l*, proceeding from *f*, but as the Refracted Ray proceeding from *h*. And that the Rays of the Sun are Refracted by the Atmosphere, has bin already proved, and is Visible to every Days Observation.

3dly, If the Rays that proceed from the several Parts of the Sun, have different *Angles of Incidence*, and can, and do pass thro' every Pore of the *Prism*, many Thousands of which, will not make one so big, as a Pore in a Hair of a Man's Head, (for if they would, they might be discerned by the *Microscope*.) 'tis scarce conceivable that, that Assertion of Mr. *Newton's* should hold good, in his First Book of *Optics*, Page 32. That the unchanged Position of the Holes in the Boards, made the Incidence of the Rays upon the second *Prism* to be the same in all Cases; Tho' these Holes were $\frac{1}{4}$, $\frac{1}{2}$, or $\frac{3}{4}$ Inch Diameter. Besides if their *Incidence* was different in the First, it would be so in the Second, because they were transmitted from the First to the Second, in the same manner that they fell upon it.

4thly, Every Part of an Object, is seen thro' a small Hole, in a darkned Room, and Painted upon the opposite Wall, tho' the Object be three Times the Length of the Hole: Here the extream Parts must send forth Rays, or they could not be Painted upon the Wall; and if they do send forth Rays, they must have different *Angles of Incidence* from those of the intermediate Points, as in the following Figure, the Rays *a g*, and *c e* have different

different *Angles of Incidence* from any intermediate Rays betwixt *a b*, and *c b*.



Why, I made a Hole thro' a Board of about $\frac{1}{4}$ of an Inch Diameter; I put my Eye pretty near to it, and could not only see it, but many Degrees of the Coelestial Arc besides. Then I took a Paper, and doubled it Four Fold, and with a Pin made a Hole thro' it, then I put my Eye within an Inch, or something nearer to it, and could see thro' it a Circumference in the Windows of a Yard Diameter at the least; tho' they were not five Yards from me: and those Rays that proceed from the extreamest in that Circumference, undoubtedly have different *Angles of Incidence* from those near the Axis, yet those came thro' the Hole, and fell upon my Eye, and from thence pass'd to the *Retina*; or else I could not have had the Sensation of any such Thing. If they did come thro' the Hole, their motion being in right Lines, if there was nothing to hinder them, they would proceed to the next Board or *Prism*, or to any given distance.

But

But that Rays having different *Angles of Incidence*, may come thro' a Hole in a Board, and thence proceed, he himself seems not only to grant, but to Demonstrate in his 24 Fig. of the first Part of the first Book, Plate 5. where he Paints the Rays, thro' the Hole *f*, Diverging till they fall upon the Lens *m n*; by which they are collected, and by it transmitted Converging to the Prism *a b c*. Now if the Rays that proceed from the several parts of a Lens to the Prism, have not different *Angles of Incidence*, at the Prism, I know not what different *Angle of Incidence* is; and if they have all his Experiments made with such Light proves nothing. For those different Refractions of Rays at *a g, e l, &c.* upon the Spectrum *p r*, may then proceed from proportional different *Angles of Incidence* in the Luminous Rays.

Mr. *Hugens* in his Conjectures concerning the Planetary World, p. 152. when he, endeavour'd to lessen the Diameter of the Sun, so as to make it appear no bigger than *Sirius*, closed on end of his 12 Foot Tube, with a very thin Plate, in the middle of which he made a Hole not exceeding the 12th Part of a Line, that is 144th Part of an Inch, that end he turned to the Sun, placing his Eye at the other, and could then see so much of the Sun, as was above a 150 times bigger than *Sirius*, which yet is much bigger than most of the fixed Stars; here the Rays, that were darted from the extreame Points of this part of the Sun, had certainly a different Angle of Incidence from those near the Axis, or any intermediate Points, yet these were brought thro' that very little Hole, that was not the 140th Part of an Inch, to the Eye at 12 Foot Distance: from whence I conceive Mr. *Newton* very unwarily

con-

concludes, Pag. 32. in his *Optics*, That the *unchanged Position of the Holes in the Boards*, made the Incidence of the Rays upon the second Prism to be the same in all Cases. For if Light whose Rays had different Angles of Incidence could pass thro' a Hole that was not the 140th Part of an Inch to Mr. *Hugen's* Eye at 12 Foot Distance, it cannot be conceived but it will do the same thro' a Hole that's $\frac{1}{4}$, or $\frac{1}{2}$ an Inch Diameter, and from this Inference he farther concludes in the same place thus : And yet in that Common Incidence (says he) some of the Rays were more Refracted and others less. And those were more Refracted in this Prism, which by a greater Refraction in the first Prism, were more turned out of the Way, and therefore for their Constancy of their being more Refracted, are deservedly called more Refrangible. But if they proceed from a different Angle of Incidence, they may as deservedly be without that Character.

And I presume Mr. *Newton* would find it a very hard Task to prove it possible for Light to be actually brought to the Eye, or to any other Place, whose Rays have not different Angles of Incidence : for all Diverging, and Converging Rays have different Angles of Incidence. And Mr. *Melyneux* says in his *Dioptrics*, Pag. 3. all Rays Diverge, and 'tis certain that all Rays that are Darted or Reflected from any Globular Body diverge in Angle proportional to their Tangents, and consequently all Rays as they flow from the Sun, or any of the Planets, or from a Candle, or any other Light, Diverge. Indeed 'tis possible for any particular Pencil of Rays to be so Refracted by a Concave Glass, that after they Emerge, they shall proceed from it in Parallel Lines : but then 'tis impossible to separate the
next

next Pencil of Rays from it, which having different Tangents, will proceed in different Lines, and consequently have different Angles of Incidence.

adly, All the Particles or Rays of Light, when they fall upon a Solid Body, are capable of being Reflected by it, as has bin proved; and every Ray of what sort soever, in Light that falls upon any Body whatsoever, if it proceeds in the same Line, and has the same Tangent, will be equally Reflected by it; because the Angle of Reflexion in all of them, is equal to the Angle of Incidence, according to his second Axiom, in which he makes no Exception: and therefore contrary to his third Theorem, they have all the same Degree of *Reflectibility*; this is evident to Sense, for if these Colours from a Prism are let fall upon a Plain Looking-Glass, each Colour will always be Reflected (tho' from twenty Looking-Glasses successively) in an Angle equal to the Angle of Incidence, each Colour constantly keeping the same place, and therefore they have all the same Degree of *Reflectibility*, and because the Angle of Emerision, (I mean the Angle made by the Emerging Ray, and the Perpendicular from the Point of Emergency) is a true Angle of Reflexion, and always equal to the Angle of Incidence, as has bin proved, they will all have the same Degree of *Refrangibility* when they Emerge into Air, and consequently are equally *Refrangible*, which must be, because Reflexion and Refraction are the same thing.

3dly, Mr. Newton says Prop. 10. Prob. 5. Page 135. Colours arise from hence, that some natural Bodies reflect some sorts of Rays, others other sorts more copiously than the rest. *Mirrors* reflects the least *Refrangible* or Red-ma-

king Rays most copiously, and thence appear Red; Violets reflect the most Refrangible, most copiously, and thence have their Colour, and so of other Bodies. Every Body reflects the Rays of its own Colour, more copiously than the rest, and from their Excess and Predominance in the Reflected Light has its Colour.

But that the several Rays of Light are positively coloured in themselves, or have a Power to make that Alteration in the Eye which we call Colour, that is, are as much Red, Green, Yellow or Blue in themselves, as *Blood* is Red in itself, or *Grass* Green, *Indigo* Blue, *Gold* Yellow in themselves: nay more, for they according to Him are Red, Green, Blue, or Yellow, but as they have power separately, or more copiously to Reflect these Red, Green, Blue, or Yellow Rays to the Eye, which single in themselves, he says, are unalterable: but the contrary seems manifest in that *Experiment* I made with a Green *Reading Glass*, or *Spectacle*, thro' which the *Solar Rays*, very near the Glass, appear very Green; which at a greater distance from the Glass are of a Lighter Green; and in the *Focus Lucid*: tho' no other Rays are added to them, or mixed with them. Nay, instead of that, there are more Luminous Rays in that large Compass of White Paper (for them to mix with,) where they are Greenest, fewer as they proceed farther, and by their Converging are collected closer, and yet appear Lighter; and fewest in the *Point of Convergence*, where they appear Lightest. Now if those Rays were Green in themselves, and unalterable (without any mixture with others,) they would be Greener, as they proceed farther, and were collected closer; and most intensely Green in the *Focus*, because that Point would be most exact.

exactly covered with their greater Numbers.

But contrary to this, they suffer as many Alterations of Colour, as they proceed from that broad Paper near the Glass to the *Focus*, as there are Degrees of Colour betwixt Green and Lucid. But the true Cause, why they appear Greenest upon that broad piece of Paper, near the Glass, seems to be this; because these Luminous Rays that before fell upon that part of the Paper in great Numbers near the Glass, so as to make it appear White, are intercepted by the obstructed Pores in the Glass, and fall therefore on that part most dispersd and fewest; and therefore make a weaker Impression in the Eye; and consequently the Phantasie of a darker Colour: but as they proceed Converging to the *Focus*, as they are contracted into less space, so they are in it more numerous, and therefore affect the Eye with more Force, and cause the Phantasie of a Lighter Colour. So that wherever Light is dissipated, or any one of those Rays that proceed from the several parts of the Sun *b, d, f*, in several Angles, is separated from the rest, either by *Refraction*, as thro' the Prism at *x, y, z*, or by *Reflexion* from the different Figured Particles in the Surface of Bodies, or from any other Cause whatsoever; it will always raise a Sensation of Colour in the Eye; if they are again collected or united they will again cause the Phantasie of a Lucid Body: and this is an Adequate Cause of *Light and Colours* in all Bodies, as has bin already shewed over and over.

I shall only take notice of one more *Experiment* of His, till I come to his Third *Book* (where I shall be very short,) and that is, His attempt to produce a *White Colour*, by the Mixture of several Coloured Powders, *Experiment 15. Pag. 110.*
and

and I shall shew, First, that that *Experiment* that he has there made, is not fair. 2dly, That all *Experiments* of that Nature that are fairly made, are in Vain.

First, 'Tis not fair in making such *Experiments* to use *Orpiment*, *Viride Aeris*, or such Ingredients that have Power to agitate and transpose the Particles in Bodies, and give them a New Modification in the Surface, and consequently Cause them to Reflect the *Solar Particles* in a different manner, and thereby cause a different Colour: as we know *Orpiment* will. For a Solution of *Orpiment* and *Quick Lime*, being put upon Writing, writ with Black Ink made of Burnt Cork, will not only take out all the Black Letters, but give a Black Colour to others, that were before Invisible, being writ with a Solution of *Saturn*. So *Oyl of Vitriol* that has it self a Black Colour, being dropt upon Common Ink, will at first, cause a White Ebullition, and after leave the Ink limpid and clear. If he should drop the same, or any other *Acid Spirit* upon the *Syrup of Violets*, it will change its Blue to a delicate Red. If he should drop *Oyl of Tartar per deliquium* upon the same *Syrup*, 'twill change its Colour to a fine Light Green. So that such Things as these, that by actuating and transposing the Particles, have Power to Cause different Modifications of them in their Surface, are not to be used in such *Experiments* as these.

But then, 2dly, if he will proceed fairly, let him take Red, Green, Yellow, and Blue Wool, (or Colours in such Bodies that have not Power to act upon each other,) and try whether by a Mixture of them, he can make White Cloth, or Cloth of another Colour lighter than the lightest of them; but this is in vain, for 'tis not the mix-

ture of several Colours, but the addition of the Luminous Rays, reflected from those several Colours into one part, that makes them appear White or Lucid ; thus, if he could take all the Luminous Rays from the Red, Green, and Yellow Colours in the Wool and Cloth, and add them to that part only, which is Blue, they would then be there in such excess, that they would enter the Eye with so much violence, as to cause a Sensation of White or Lucid : And thus it is in the *Prism*, when the Rays that are scattered into those several Colours, are added or collected into the Space of one of them.

In the Third Book *Obs. 1st Pag. 114.* He says, I made in a piece of Lead, a small Hole with a Pin, whose breadth was the 42th Part of an Inch. Thro' this Hole I let into my darkned Chamber a Beam of the Sun's Light, and found that the Shadow of Hairs, Thred, Pins, &c. were considerably broader than they ought to be, if the Rays of Light pass'd on by these Bodies in right Lines.

And particularly a Hair of a Man's Head, whose Breadth was but the 280th Part of an Inch, being held in this Light, at the distance of about 12 Foot from the Hole, did cast a Shadow, which at the distance of four Inches from the Hair, was the 60th Part of an Inch Broad, *i. e.* above four times broader than the Hair, and at the distance of two Feet from the Hair, was about 28th Part of an Inch broad, that is, ten times broader than the Hair ; and at the distance of ten Feet, was the eighth Part of an Inch broad, that is, 35 times broader.

From whence He concludes, *Pag. 115, First,* that the great breadth of these Shadows proceeds, from some other Cause than the Refraction of the

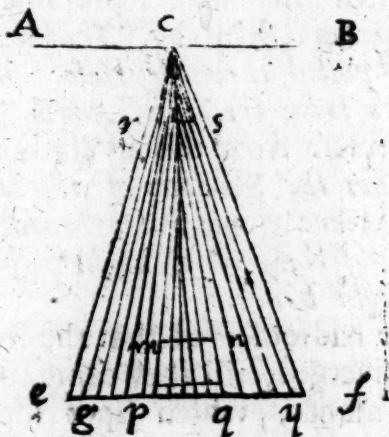
the Air, 2^{dly}, that the Hair acts upon the Rays of Light, at a good distance in their passing by it.

Both which inferences, I presume are founded upon His general Mistake, *That all the Rays of Light that passed thro' the Hole, proceed in Parallel Lines from the same Angle of Incidence*; as seems evident from those Words above, where he says, *That the Shadows of the Hairs, Thred, Pins, &c. were considerably broader than they ought to be, if the Rays of Light passed on by these Bodies in right Lines.*

But if he had observed that the Rays from the Hole had diverged, till they came to the Spot at 12 Feet distance, which Spot I presume was there as many times bigger than the Hole they came thro', as the Shadow of the Hair at ten Feet distance, was broader than the Hair it self; and if so, the Shadow was no broader than it ought to be, for the Hair must cut off many more Rays at ten Feet distance, than at two, and at two Feet, than at four Inches distance, and consequently make a Proportionably greater Shadow at ten Feet, than at the lesser distances, which if the Lines had bin Parallel (as he makes them in the Figure till they bend,) they would have done.

For Example, suppose c a Hole in the Board AB , thro' which the Rays of Light pass, Diverging to the Paper ef ; 'tis evident that the Line rs , at ten Feet distance, cuts off all those Rays betwixt g and y , and consequently makes a Shadow as far; whereas the Line mn , at two Feet distance, cuts off but those betwixt p and g , and therefore makes no bigger a Shadow, and the Line at four Inches distance fewer, and the Shadows in all places must be bigger, than if the

Rays had bin Parallel, because they all Diverge.
So that there is no necessity for the Hair to act



upon them at a distance, and their Divergency is an evident Proof, that they proceed from a different *Angle of Incidence*.

I conceive, the Fringes in the following Experiments are produced from the Irregularities in the Surface of the Bodies, they are Reflected from, (and there is very few Bodies, but what have such Irregularities; for Mr. *Leeuwenhoeck* has discovered Notches like a Saw even in the Edge of a Razor, with his *Microscope*,) and from the roughness of the Edges of the Hole, and the Irregularity of their Reflexion, in their passage thro' it.

C H A P. XXVII.

THirdly, As the *Solar Particles* are contrary to the *Nitro-aerial* and *Nitro-terrene Particles*, they will account for the *Phænomena* of *Alkaly* and *Acid*, *Magnetism*, *Sympathy* and *Antipathy*, *Electrism*, and the Coldness of the Middle Region.

First, As the *Ætherial Particles* are indued with a Spring contrary to the *Nitrous*, (as has bin proved, and therefore resist and fly from each other in an open Medium, and clash, and strive with, and tear each other, when confined together: It will follow, that where either of them are Concentrated in a Body, they will Resist and Beat off their contraries, that float in the open Air, and by so doing will not only admit, but make way for those that are Similar, to fly to them, and to unite with them: as has bin abundantly proved by *Glauber's Concentrated moist Fires*, &c.

By which I conclude, That as the *Nitrous Particles* of the Air and Earth flow to those Fires, so they do to all *Acid Bodies*, (and circumsolve them, and unite with them,) as to a Place where they can be most at rest from their *Ætherial Enemy*; and that the *Ætherial Particles* flow to all *Alkalizal Bodies* for the same Reason.

Now all *Saline Particles*, I take to be Angular, as they appear to be by the *Microscope*, and not very Porous, but Solid, as they seem to be by

their Weight ; and consequently those in which either those *Acid* or *Alkaline* Particles are embodied, must be so too : So that when an *Acid* Liquor, and an *Alkaly* are mixt together, by reason of the Luctation that arises betwixt the *Ætherial* and *Nitrous* Particles, which immediately set upon each other, like Fire and Water, the more Gross and Solid *Saline* Particles, in which the *Ætherial* and *Nitrous* are deeply and numerously intruded, are put into a Rotation, and by Jostling against each other, break off their Corners ; whilst the *Ætherial* and *Nitrous* Particles, by Extricating themselves in this hurry, mutually shatter the *Saline* Bodies, and alter their Figures. And so whilst the *Ætherial* and *Nitrous* Particles ascend in a huff to the Superficies, the *Saline*, close (being Similar) and Subside to the Bottom, and make a Body differing from either of them they were before, or rather compounded of both ; as in *Tartar Vitriolate*, which conflict we attribute to what we call *Alkaly*, and *Acid*, that is, to the *Ætherial* and *Nitrous* Particles, as they are combined with other Bodies, particularly the *Saline*. That the Solar Rays are embodied, is evident by this, that they add to the Weight of many Bodies, in *Calcination*, e. g. *Mercury* Calcined by the Rays of the Sun, Collected by *Burning Glasses*, will encrease considerably in Weight, as many other Bodies will in the Fire : From whence they chiefly take their *Alkaline* Nature, as is manifest, because there is nothing highly *Alkaline*, but what has gone thro' a high Degree of Fire.

2dly, These *Ætherial* and *Nitrous* Particles, being Principles disseminated throwout the *Universe* ; even from the Highest Firmament, to a considerable Depth, (as is evident by Freezing,)

if not to the Centre of the Earth: It is plain,
1st, From this Contrariety of Nature in them ;
 That the Impulsive Force of the Solar Particles
 acting upon the *Nitrous*, must necessarily cause
 a perpetual Flux of the *Nitrous*, from that part
 of the Earth that is immediately posited under
 the Circuit of the Sun, and the rest of the Pla-
 nets, (*i. e.*) from the *Equator* to the *Poles*.

That these *Nitro-aerial* or *Nitro-terrene* Parti-
 cles, are disseminated thro' are parts of the
 Earth, is evident from this *Experiment* ; that if
 you heat an Iron Red, and let it cool perpendi-
 cular to the Earth, in any part of our Northern
Hemisphere, its lowest end will gain a Verticity
 towards the North Pole: If you do so in any part
 of the Southern *Hemisphere*, its lowest end will
 gain a Verticity towards the South Pole, which
 shews, that there must be *Effluvia* from all Parts of
 the Earth, that can affect Iron, in the same manner,
 as if it had bin touched with the *Load-stone* ;
 and consequently those *Effluvia* may be presumed
 to be of the same Sort, as those that flow from
 that Stone are, Which seems to be confirmed,
1st, Because the *Load-stone* is generated in the
 Earth, and is more easily altered by the Air, and
 therefore its *Effluvia* may be supposed to be Si-
 milar too, if not the same with those, with
 which the Earth and Air abounds. *2dly*, Be-
 cause if you take the Needle thus impregnated,
 and heat it, it will loose its Verticity ; but if
 you quench it in the Earth, or let it cool Per-
 pendicular, it will again imbibe like Particles,
 and reassume its former Virtue, because the *Æthe-
 rial* and *Nitrous* Particles mutually expel each
 other. *3dly*, the very fine Filings of Steel held
 over a Candle, will flash like Gun-Powder,
 which shews they participate much of *Nitre*.

3dly,

3dly, Tho there are Nitrous Particles in all parts of the Earth, yet they are not all exactly of the same sort, but that those in one part of the Earth, differ from those in another part of the Earth, in some respects: (*viz.*) those in the Northern from those in the Southern Hemisphere. This is reasonable to suppose, because we find the Southern Hemisphere, produces different *Animals, Vegetables, and Minerals*, from Ours, and therefore very probably consists of different Earths from Ours: From whence these *Nitrous* Particles receive a different Texture or Modification from Ours; so that those Southern *Nitro-aerial* Particles are not so Similar to the Northern, as to unite withthem, where ever they meet them.

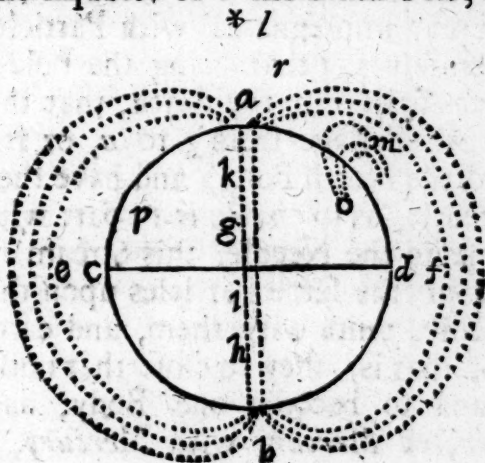
But when impelled by the Solar Rays, proceed in separate Streams (near the Earth) always towards the South, tho' in Our Hemisphere, as Ours do always towards the North, tho' in the Southern Hemisphere.

As in the Figure, Suppose *a b c d* to be the Earth, *a* the North Pole, *b* the South Pole, *c d* the Equator, *e f* the height of the lower Region of the Air under the Equator, or that place where the Solar Rays reflected, diverging from the Earth, become so separate, or at such a distance from each other, that they loose their Power, or have but a weak Heat, (being so dispersed to what they have near the Earth.

Now suppose *g* a Stream of *Nitrous* Particles raised in Our Hemisphere, and impelled by the Rays of the Sun, from the Equator towards *a* the North-Pole, from thence towardt *l* the North-Star; but being cruder than the *Nitrous* Particles of those Upper Regions, they cannot ascend thither, but sinking by their own Weight; and

and being impelled behind, by fresh supplies continued from the Equator to that Pole, they bend at *r* towards *m*, and from thence thro' the Middle Region of the Air, by *f* to *b*, the *South Pole*, where descending to the Earth, they again proceed Northwards to *h*, and so to the Equator.

So in the Southern Hemisphere, suppose *i* a Stream of *Nitrous* Particles impelled by the *Sun* from the Equator to *b* the *South Pole*, and from



thence by *e* to *a* the *North Pole*; when they descend to *k*, as well thro' the Surface of the Earth, and all *Minerals* in the Earth, as above in the open Air. That they do pass thro' the Earth and its Minerals, we may easily conclude, since they pass thro' all Bodies (except Iron to which they adhere,) without any let or hinderance, even thro' Gold it self, thro' a Man's Head, or Body, or the *Vacuum Bolyeanum*, as is evident by the Effects of the *Magnet* upon the *Mariners Needle* thro' all these Mediums; so that 'tis as easie for them to pass thro' the Earth and its Minerals, as thro' the Air.

Now

Now if in their Passage *North*, or *South*, they meet with any Particles that are Similar to them, they close with them : and if they are free (*i.e.*) if hanged so nicely upon a Pin, or Thread, as to incline easily this way or that, they Force them along also.

Thus, if that Stream of *Nitrous Particles* raised by the Sun in our *Northern Hemisphere* at *g*, meets with that Point of the *Needle* that has bin touched upon the *Southern Pole* of the *Magnet*, and is thereby impregnated with Particles Similar to themselves, (that being the Pole of the Magnet, as it lies in the Earth, that they beat upon in their Passage from *g* to *a*, or from the Equator to the North Pole,) and have thereby so impregnated it, as to enable it to part with some of the same to the Needle, this Stream meeting with some of the same Particles upon the Point of the Needle, unite with them, and carry them along also, that is, they so close that nothing intercedes, and so become one Body, as *Water* with *Water*, or *Mercury* with *Mercury*, so that they can with more ease be forced along together, than be separated from each other, 'till they have carried the Needle so far as 'tis free to go, that is, to Point towards the *North*. Which is the Reason that that Point that is touched upon the Southern Pole of the *Magnet*, in our Hemisphere always turns from the Equator towards the North Pole, with some little *Variation East* or *West*.

Which *Variation* is greater or lesser, as they are nearer to, or farther from the *Pole*; For the *Nitrous Particles* are not at all impelled by the Sun, directly towards *a*, but towards *l*, so that if the Needle were placed at *a*, it would not Point toward *a*, but towards *l*, and because the

Stream

Stream there has some breadth, it proceeding from the whole Hemisphere of the Earth, and tending towards the *North Star*, that is at the greatest distance from the Equator, it would vary from the Pole of the Earth, as you see in the *Figure*. Besides the bending of the *Nitrous* Particles there towards *m*, may cause it to vary farther towards the *East*, supposing *f* the *East*, or if it were at *p* towards the *West*.

But if the *Needle* were placed at *a* the *North Pole*, it would incline every way alike, because the *Nitrous* Particles streaming from all Points of the Equator to the Poles in Lines parallel to the Axis, would equally affect its Points, which way soever it turns.

In like manner, if the *Needle* were under the *Equator*, it would have no Propension more one way than another, because the Particles there raised, have as much Inclination to one Pole as the other, or an equal Tendency to either, being at an equal Distance from both.

These Effects are constant, except those *Nitrous* Streams from the Equator to the Poles are diverted by some interjacent Body, as a *Loadstone Island*, &c. For 'tis evident, that if the *Needle* comes within the Atmosphere of the Loadstone, it will leave the *North Pole*, and turn to the Stone, tho' East or West; the *Nitrous* Particles bending that way, because they there find less Resistance from their *Ætherial* Enemy, that space of the Air in which the Magnet lies, being more impregnated with *Nitrous Effluvia* from the Body of the Stone, and therefore more Similar to them; to which they will therefore turn, for the reason above mentioned, under the Title of *Acid* and *Alkali*.

The

The Earth being in all places full of *Nitrous* Particles, if the *Needle* approaches an Island (far distant from the Continent,) it varies from the Pole, and turns towards the Island : for the same Reasons, and in the same manner as 'tis observed to leave the Pole and turn toward the *Loadstone*.

4thly, Tho' those *Nitrous* Streams on each side the Equator, have from those Climes, such a different Modification, as not to unite with each other, yet being the Emanations of the same Body, viz. the Earth, do both find Similar Pores in the *Magnet*, thro' which they would indifferently pass, were not some of those Pores prepossessed by those *Nitrous* Streams, that flow from the Equator to the North Pole, and others by those that flow from the North Pole to the Equator; by which the Pores of the *Loadstone* are so disposed like Veins and Arteries, that those *Nitrous* Particles that are raised in our Hemisphere can, and do easily pass thro' these, but not thro' them, whilst the other can and do readily pass thro' those, but cannot thro' these, and either can carry with 'em, Common *Iron* to the Magnet, to which they are both indifferently Similar. But if the Texture of the Pores or Particles of *Iron* are altered, prepossessed, or covered with *Magnetic* Particles, by being touched upon either of the Poles of the *Loadstone*, then only those Particles have power to carry it along with them; which beat upon that Pole of the *Loadstone*, (when it lay in the Earth) on which it was touched; and the contrary resist it; as for Example, if you touch the *Needle* upon the Southern Pole of the *Loadstone*, then those *Nitrous* Particles that flow from the Equator, can only carry it to the Southern Pole of the Stone, upon which Pole

Pole they beat in their Passage towards the North; but if there be no Loadstone in their way, then they will carry that Point of the Needle which was touched upon the *South Pole* of the Loadstone, so as to make it Point towards the North; which is therefore called the *North Pole* of the *Needle*, and so on the contrary.

That the Pores of the *Magnet* are indifferent to the *Nitrous* Particles in either Hemisphere, is evident by these Experiments of Mr. *Boyles*, in His Book, *Of the Usefulness of Experimental Natural Philosophy*, where He says, That an Oblong Loadstone heated red hot, lost its attractive Virtue, but by cooling it again, he gave its Extrems a Polarity, and by cooling the same end, sometimes North, and sometime South, chang'd the Poles at pleasure. The same Polarity, as he mentions in his *Magnetic Experiments*, he has observed in a piece of Brick or Earth, burnt and cooled in the same posture.

He says farther, That tho' it is a peculiar Quality of the Loadstone to Point North and South, yet without destroying the substantial Form by Fire, the Poles may very easily and speedily be changed, if a small Fragment of a Loadstone has its Poles successively applied to a very vigorous *Magnet*.

Those Experiments shew plainly, 1st, That the *Magnet* receives its Polarity from Terrene Effluvia, that stream from North to South, and back again; otherwise the *Loadstone* would be no more affected or impregnated with *Magnetic* Particles by cooling in this posture, than in any other.

2^{dly}, That 'tis not any different Figure in the Pores of the *Magnet*, that appropriates them only to admit these *Nitro-terrene* Particles that are
arised

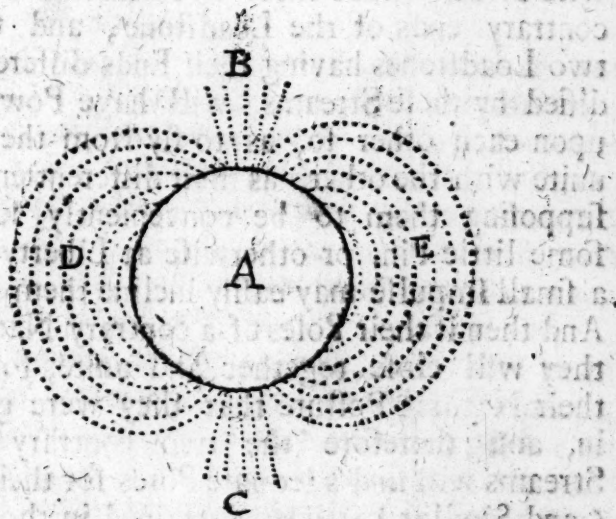
raised by the Sun in the Northern Hemisphere, and to repeal those of the Southern, and the contrary. But the prepossession of either sort of these Effluvia in those Pores; otherwise he could not have altered the Polarity at pleasure, the Fiery Particles being equally contrary to both of them, and equally puts both to flight, or banishes both from the *Magnet*, and therefore leaves its Pores and Poles free to be possessed by either; and then the Stream in our Hemisphere proceeding from the Equator to the North, by reason of the violent Impulse of the *Sun*, must be stronger than the opposite, and therefore cause the Polarity in that end that was opposed to it: and the vigorous *Magnet*, by its numerous Effluvia, forces the few in the Fragment that make but a weak Resistance back, and takes possession of their Pole, which they could not do, were not the Pores adequate to either.

And if the cooling of the Stone North and South will cause a Polarity in the *Magnet*, it will certainly follow, that the *Magnet* that is generated in that posture, will thereby obtain the same Virtue, from those Streams that flow thro' its Pores North and South.

That there are such contrary Streams in which its Virtues consists, seems farther confirmed by these *Experiments*; that if the Needle be drawn from the Pole of a *Loadstone*, towards the Equator, and you hold the Point towards the Pole, it gains a respect to one of the Poles: but contrarywise, if the Point of the Needle be held toward the Equator, it gains a respect towards the contrary Pole.

2dly, If you take a piece of Paper or Pastbord, and cut a Hole, and put a *Loadstone* thro' it, so that the Paper or Parchment may close well to
the

the *Loadstone*, then keep it in a Level or Horizontal Posture, and Sprinkle some fine Filings of Steel upon the Paper and *Loadstone*, and you will find the *Loadstone* will dispose the Filings in such Lines, as in the Figure. In which suppose *A* the *Loadstone*, *B* the *North Pole*, *C* the *South Pole*, *D E* weaker Streams flowing out of one part of the *Loadstone*, and in at another, being beat back by those Particles that always flow to

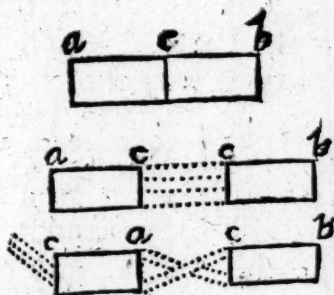


the *Loadstone*. That these are two contrary Streams at *B* and *C*, which constantly flow toward *A* is plain by this, that either of them is capable of carrying Iron to the *Loadstone*, which they could not do if both circulated the same way, that is, if these that stream out at *B* always turn back by *D* and *E* to *C* (or the contrary;) from thence again to *A*, and so on to *B*; for if so, they could only, and would always carry Iron to the *South Pole* of the Stone, but never to the *North* (or the contrary) because
T
there

there the Particles would flow from the Stone towards *B*, and consequently would always repel the Iron from that Pole, which is contrary to Observation.

'Tis evident from this *Experiment*, that the Virtue of the Loadstone is communicated by way of Streams, and that in it there are two contrary Streams, for otherwise the Motion of the Needle this way or that, could not change the Efficacy of the same parts of the Loadstone. It is likewise evident, that those two Streams are at the contrary ends of the Loadstone; and therefore two Loadstones having their Ends differently modified by these Streams, will have Power to act upon each other so, as to fly from the one and unite with the other, as their different ends meet, supposing them to be conveniently set, upon some little Pin, or otherwise at Liberty, so that a small Impulse may easily incline them any way. And then if their Poles of a contrary Name meet, they will close together and unite, for this is their Natural Posture that they were generated in, and therefore the two contrary *Nitrous* Streams will find adequate Pores for their Passage (and Similar Particles contained in those Pores) in the opposite Ends of the Loadstone, without any Disturbance, as they did before it was taken out of the Earth, and the crowding in of these Streams at the opposite end of the Loadstone will thrust the two other together, and make 'em unite, as in *Fig. 1.* let *a b* be a Loadstone, let *a* be the North Pole, *b* the South Pole thereof thro' which the contrary *Nitrous* Streams pass with equal Facility; let the Loadstone be divided into two at *c*, and make the Loadstone *a c*, and *c b*, in *Fig. 2.* In one of which *a* will be the North Pole, and *c* the South Pole, in the other *c* will

c will be the North Pole, and *b* the South Pole.



Now the two *c c*, being the North Pole of the one, and the South Pole of the other meeting, they will be in their natural Posture, as they were in before they were separated at *c*, in Fig. 1. and consequently, the contrary *Nitrous* Streams will find the same free Passage thro' them, and will impel them and unite them again, as they were before in Fig. 1. But if the Poles of the same Name as *a c*, Fig. 3. meet, they will be in a Position, contrary to the Natural Situations, and therefore the two Streams beating upon contrary Poles, will find no Passage, and for that Reason, force them to move Obliquely to each other: the same is to be observed in two Touched Needles, and for the same reason.

Mr. Boyle says in his 5th Experiment, that if an Oblong Loadstone be cooled in a Perpendicular Posture, its lower end becomes its Northern Pole, but if that end, instead of exposed to the Effluvia of the Earth, be cooled whilst resting on the Northern Pole of a strong Loadstone, it will be the Southern Pole, and will Attract the North end of the Needle.

I conceive the Cause of this *Phænomenon*, to be the weakness of the Effluvia that arise Perpendicular from the Earth ; which is such that they cannot force their way thro' the Pores of the *Loadstone*, but beating upon its lower end, they adhere to it, and plant themselves upon, or in its Surface, as they do upon Iron for the same Reason, *viz.* because they cannot pervade its Pores, as they do the Pores of all other Bodies. As is evident from this, that if a *Mariners Needle*, fixed as it ought to be, be set upon a Plate of Iron, and the *Loadstone* moved under it, the *Loadstone*, will not at all affect the Needle, because its Effluvia being Similar, are withheld by the Plate of Iron, but if the Needle be set upon any other Body whatsoever, and the *Loadstone* be moved under it, 'twill have its effect upon the Needle: and therefore these *Nitrous Effluvia* being not able to enter the Pores of the *Loadstone*, when their Similar Particles were put to Flight, and the Particles of Fire possess their Places, they only fix upon its Surface at the Lower end of the *Loadstone*, as they do upon Iron; and are carried with it, like the Needle to the North, by the Stream of *Nitrous* Particles that flow from the Equator. But if that end be cooled, whilst resting on the North Pole of a strong Magnet, it will be the South Pole, and will Attract the North end of the Needle; because the *Nitrous Effluvia* being collected by the strong *Loadstone*, upon whose North end it cooled, will force their Way with Vigour thro' its Pores, and so give it again the Nature of a true *Loadstone*, which it had (at least in a great measure) lost before, by the action of the Fire.

And because these *Nitro-terrene* Particles will not pass thro' Iron, but by reason of their Similitude adhere to, and condense upon its Surface;

a Reason may be assigned, why a *Loadstone* that is Caped with Iron, will take up much a greater Weight of Iron, when it touches it, than it will do when naked or unarmed, and yet it will not attract it at so great a Distance as when Unarmed. For the Plates of Iron fixed upon the Poles of the *Loadstone*, thro' which the *Magnetic Effluvia* cannot pass, but by Reason of their Similitude will be retained by them, must be highly impregnated, and covered with those Effluvia; so that the dissimilar Parts of the Air near the Iron Plates will be quite banished or drawn off by the Multitude of these *Effluvia*, and then when any other Iron is applied to the Ends of these Plates, nothing will intercede but these friendly Particles, which will only serve as a Glue to unite them. And consequently the Pressure of the Atmosphere, which is equivalent to the height of a Pillar of *Mercury* of 29 or 30 Inches long, will hinder them from separating: (and I am confident, I have seen a *Loadstone* hang to a Key by the ends of those two Plates fixed upon its Poles, at least equivalent to the Weight of two Pillars of *Mercury* 30 Inches long, of the bigness of that part of the Key that touched those Plates. But then on the other hand, these *Nitrous Emanations* which were wont to flow to the Magnet in right Lines, and Concentrated at its Poles, will be scattered and divided from their wonted Course by these Plates; and consequently cannot carry any thing along with them that is at a distance, with so much Force to the Magnet, as they did before.

There are other *Phænomena* of the *Magnet*, but all aptly and easily solved by these Principles.

ably, There are *Electrical Bodies*, such as *Yellow Amber*, *Jet*, *Sealing Wax*, &c. that are generally of a *Bituminous Unctious Nature*, as ap-

appears from their Inflammability, Smell, and *Chymical Analysis*, that upon a little Agitation or Rubbing, have Power to Attract light Bodies, as Straw, Paper, &c. to them, and to retain them sometime : Which I conceive is performed after this manner ; the agitation of the Particles of *Amber*, &c. by Rubbing, causes a Rarification of the Air contained in its Pores, which being Rarified must take up more room, and consequently cannot be contained in the same place, but will force its way out with Violence, and in so doing will drive those loose Unctious Particles in these Pores, that participate of the same Nature as the Whole, (and are those that are the Cause of Smell in all Bodies whatsoever,) out also : these Rarified Particles, as soon as they come into the open Air, will be Condensed by its *Nitrous* and *Aqueous* Particles ; which being Condensed, the Unctious Particles will be drove back ; and in their return being Numerous (as appears by the strong Smell of Amber, if it be immediately put to the Nose upon rubbing) will throng upon each others backs, and being Similar will close with each other, and unite in little Lines or Threads, which being of an Unctious Nature, will be repelled back again by the Pressure of the Air, as Oyl from Water, or as Contraries from each other, to the place from whence they came : and as they retire will carry any light thing along with them, that an *Unctious* or *Bituminous* Body is apt to adhere to.

The Reason why all Bodies are not *Electrical*, (there being none but what have Smell at least upon Rubbing) is, because their *Odoriferous Effluvia* do not always meet with Particles in the Air that they are apt to adhere to, and that they are strong enough to carry along with them : Or possibly

sibly they may not be so dissimilar to the *Aerial* Particles, as to be impelled back again by them, to their own Bodies, but may disperse in the Atmosphere, and mingle with such Particles they find therein Similar to themselves.

5thly, That the Healing of Wounds by the *Sympathetic Powder* or *Weapon Salve* is done by *Effluvia*, is evident from the Requisites that are necessary in the performing thereof; for the Powder must be sprinkled upon a Linnen Cloth wet with the Blood fresh from the Wound; or dissolved in a sufficient Quantity of Spring Water, and a Cloth that has the Gore dried upon it must be put therein, or the Salve must be applied to the Weapon before 'tis cleansed; or the Weapon must be put into the Wound again to make it effectual when Dress'd; and then they must be kept in a moderate Heat, such as the Beams of the Sun in the Spring, and in a free or in the open Air.

For if the Bloody Cloth, with the Powder sprinkled upon it, or put into the Vitriolated Water, or the dressed Ax with the Edge downwards, be put into a cool Cellar, where the Air is stagnant, the Cure will not succeed. If the Vitriolated Water with the Rag in it, be suffered to freeze, the Wound will be affected at first with a Sense of Cool or Shivering; but if it be quite Froze up, the Wound will neither find Good or harm by it. If the Bloody Cloth be taken out, and dried by a Hot Fire, the Wound is Inflamed, and afflicted with a violent burning Pain. If the Bloody Linnen be washed with a *Lixivium* or Vinegar, that may fix or totally carry off the Spiritous Particles of the Blood, and then put into the Vitriolated Water or Powder, it will have no Effect at all. If it be washed in

Spring Water, it will do something; but will not have equal Efficacy with that, that is not washed at all; so of the Weapon.

From hence 'tis plain, that for the performing of this Cure, there must be a Mixture of *Sanguineous* Particles with the *Vitriolic*, and consequently the Cure however it be effected, must proceed from this mixture. 2dly, 'Tis plain, that it cannot proceed from the immediate Application of this Mixture to the Wounds, which may perhaps be 20 Miles distant; and therefore it must proceed from *Effluvia* (which probably reflect from the Luctation of different Particles in this Mixture,) and flow from it to the Wound.

That this does proceed from *Effluvia* is evident, 1st, From this, that the Cure may be Accelerated by those things that excite *Effluvia*, as by a moderate Heat; and Retarded by those things that fix and hinder this *Effluvia*, as Frost, or a Stagnant Air.

2dly, Because the Effects will be stronger, or Weaker as there is a greater or lesser Quantity of *Sanguineous* Particles mixt with the *Vitriol*. For if the Bloody Cloth be washed in Spring Water, and then put into a *Vitriolated* Water, the Effect will not be totally abolished, but much weaker than if it had bin put in unwashed. But if the Rag be washed in Vinegar, or in a *Lixivium*, which either fix or totally carry off the *Spirituuous Alkaly* Particles of the Blood, it will have no Effect at all. By which it appears, that this Effect may be lessened, or advanced, or totally destroyed at pleasure; which shews that it depends upon this Mixture, and therefore can Operate no otherwise than as Matter, which therefore being at a Distance must be by *Effluvia*.

But

But then it will be enquired, *first*, how these *Effluvia* are directed to the Wound. *2dly*, Whether they are proper to work such an Effect, if they do come to Wound. *3dly*, If they are proper, and do come to the Wound, whether it may be supposed to be in sufficient Numbers to perform the Cure.

First, 'Tis certain, that from the Mixture of the *Oleaginous Alkali Salt*, and Spirit of the Blood, there will be a Luctation with the Acid *Vitriolic Particles*, from which there will arise *Effluvia* Participating of both Nature; which will therefore be *Heterogeneous* to any of the Atmospheric Particles, and consequently will be impelled by them, to move in that Line, in which they find Particles most Similar to themselves; which must be towards the Wound, because all along from thence there has bin *Effluvia* proceeding from this Mixture, or the Bloody Cloth, which being scattered in the Air, and by it impelled to the Ground, will be lodged upon the Grass, &c. and there remain in a Line to the place where this Mixture is, tho' at a very great Distance, as the *Effluvia* from the Foot or Body of a Hare, or other Animals will lodge upon the Ground, and there lie in a Line to many Miles distance, and be perceptible to Dogs, and other Hunting Animals many Hours, if not Days after: and possibly some Foot Steps of it may remain there, even after 'tis imperceptible to Hounds, Spaniels, or the most acute Hunters: But if not, yet so long as *Effluvia* do arise from the Mixture, and pass by this Line to the Wound, it must be continued tho' to some Days or Months, and will be until the *Volatile Saline Particles* have extricated themselves from the Terrene and Gross *Oleagenous Particles* of the Blood, which perhaps may

may be much longer in doing than is usually imagined ; tho' Actuated by a Moderate Heat, as many Relations would make out.

But that the *Effluvia* from this Mixture are likely to continue long upon the Grass, &c. appears from this, That if the Bloody Cloth be washed with Spring Water, the effect will be only weakned not destroyed ; which shews that the Particles that are effectual for this purpose, are so combined with the *Oleaginous*, as not to be easily miscible with Water, nor consequently with Air, which abounds with Aqueous Particles : and therefore these *Effluvia* may long continue in it ; and by reason of the impulse of the Air may pass with great Celerity by this Line to the Wound.

2dly, These Particles seem proper for these Effects, (i. e.) for Healing of the Wound ; First, as they participate of Vitriol, and are therefore Cooling and Astringent, by which they take off the Inflammation, and gently close the Mouths of the Vessels. 2dly, As they participate of *Sanguineous* Particles, so they are similar to the Juices contained in those Vessels, and therefore Unite with 'em, and thereby joyn them together or Heal them.

3dly, 'tis manifest from what has bin said of the Exceeding Subtily and Fineness of *Ætherial* and *Nitrous Particles*, that a very small quantity in bulk, will supply a very numerous *Effluvia* : And that all *Alkaly* and *Acid*, (and consequently those of Blood and Vitriol,) are *Ætherial* and *Nitrous Particles*, concentrated and embodied, or combin d with other Principles, by which as they receive different Modifications, so they are capacitated to have different Operations upon the Animal, and all other Bodies.

And

And I apt to think, that 'tis from the Motion and Contrivance, or Structure of these most Minute and Imperceptible Parts of Bodies, that the Efficacy of most, if not of all *Medicines* whatsoever depends, and not from the Bulk of those Gross Ingredients, that are visibly at rest.

To confirm the Truth of this Conjecture, I could give many Instances, as 1st, that of *Antimony*, an Infusion of the *Liver Glass*, or the *Regulus* of which, in Wine Posset drink, &c. without any sensible Alteration in the Liquor, or wast in it self, will so impregnate it with its Effluvia, as to cause it to be strongly Emetic, so as to put the Stomach and adjacent Parts into Violent Convulsions, and almost shake the whole Animal Oeconomie to pieces. 2^{dly}, It has bin positively affirmed to me that a Dose of *Extra-ctum Rudii*, made up into Pills, and well Gilt, have worked very well, yet come away undissolved, and the Gilding not in the least broak.

3^{dly}, Dr. *Buck*, who was a Man of great Ingenuity and Candor, shew'd me the *Lapis Nephriticus*, which he wore in his Bosom, being subject to that Disease, and told, that 'twas not only serviceable to him therein, but was of such Efficacy, that it would tinge his Urine of a Greenish Colour, so oft as he wore it, yet without the Perception of any thing from it, or any Alteration in it.

Many other Arguments may be taken from the Honourable *Boyle's Discourse of Languid and Unbeeded Motion*, and His Treatise of *Specific Medicines*; but these are sufficient (with what has bin said before, all along,) to shew that the Efficacy of Medicines may be very Powerful, and their Effluvia numerous enough, to exert that Power, tho to Sense Imperceptible.

The

The *Weapon Salve* composed of *Scull Moss*, *Mummie*, and *Man's Fat*, has *Stiptic* and *Oleaginous Balsamic Particles*, which latter are *Similar* to the *Animal Juices*, and *Heterogenous* to the *Air*, and therefore perform the same *Effects*, (as may be supposed,) for the same *Reasons* as the other.

C H A P. XXVIII.

4thly, **A**S they have a *Rotation* upon their own *Axis*, they are the *Cause* of *Ascension*, and its *Relata*; for as they enter into the *Pores* of the *Bodies*, as suppose of *Vegerables*, they first *Act* upon the *Aerial Particles* they find in their *Tubes*, dilate them and drive them out: upon which the *External Air* rushes more violently in, and drives out, not only the *Aerials*, but 2dly, those *Aqueous Particles* indued with a *Contracting Spring*, which being then easiest moved, the *Ætherial Particles* next set upon; and by closing with them, in their *Rotation*, stretch their *Springs*, and unwind them so, that they are sometimes themselves wrapped up in them, and fly with them. As is visible in a bright *Brass Pot*, in the bottom of which, being set with clean *Water* upon the *Fire*, you may see little *Globules*, in which the *Ætherial* or *Fiery Particles* are wrapped up; and when they are expanded so far, as to be lighter than *Water*, you will see them ascend to the *Surface*, and fly away in a *Fume*, which *Ascent* of them will increase, as the *Pot* grows *Hotter*, till at last,

will be in so great numbers, as to put the Water in such an Agitation, as we call *Boyling*. The *Aqueous* Particles in the Pores of *Vegetables* being thus unbent, or stretched out, take up more room, and are then what we call *Rarified*, and so force their passage thro' the Pores and Tubes, in the same manner and way, as the *Aerial* did before. And being thus rarified, and rapidly forced out in great numbers, cause that *Phanomenon* we call *Smoke*.

3dly, These being separated, and the Rotation of the *Aethereal* Particles being still continued, and their numbers encreased, being collected by a *Lens* or *Burning-Glass*, they will next set upon the *Oily* or *Sulphurous* Particles; which being in some measure Similar to them, are easily put into a like violent Rotation with them: In which Rotation they will likewise act upon those *Nitrous* Particles that are combined and united with them. Upon which they will break out together in *Flashes*, like *Niter* and *Sulphur* compounded in *Gunpowder*, and incited to a Rotation by Fire: Which *Flashes* being dilated by *Aqueous* Particles, and numerously forced thro' the Pores and Tubes, cause that *Phanomenon* we call *Flame*.

4thly, *Flame* consisting of Particles thus violently Agitated, has Power to act upon others, and give the like Motion to them, which will be continued till all the *Aqueous*, *Nitrous*, and *Sulphurous* Particles be separated and evaporated, and then the Bond of Unity, and adhesion will be dissolved, and the *Terrene* and *Saline* Particles being disunited, will be reduced into that Powder we call *Ashes*.

That

That the Action or Power of *Fiery* Particles depends upon their Rapid Rotations, is visible in those Sparks that fly from a *Flint* and *Steel*, which falling upon the Sulphurous Parts of *Gunpowder*, according to the *Hypothesis*, will impress or excite a like Motion in them, as is also visible in its Flashes, and Smoak flying away in Curles. This Rotation is yet more manifest in the Cupelling of Mettals, where you may plainly see the Heterogenious Mettals whirling about in bright Spots.

And that the *Watry* Particles are separated by Fire first, and the *Oyl* and *Acid Spirit* being combined together follow next, is visible in every Distillation; which Acid Spirit is *Niter*, as has bin proved before, and the *Nitrous* and *Sulphurous*, being combined together in the wood of Vegetables, will have the same Power to act upon each other, in proportion to their mixture with other Particles, as they have in *Gunpowder*, and consequently proportionally cause the same Effects, when actuated by Fire or *Æther*. So that Culinary Fire seems to be produced chiefly by the violent motion of these two contending Principles; which being mixt in an equal proportion throwout the Compound, by their Luctation, dissipate all the Particles of the Body, being assisted by the blast of the External Air; which at the same time that it drives the *Ætherial* and *Fiery* Particles more forcibly into the Minute Pores of the Body, is its self Rarified by them, and helps to rend the Body in pieces, and carries away its Fluid and Expansive Parts in a Flame.

But sibly, If there be a *Medium* as in Distillation betwixt the Body and it, that hinders the External Air from it, then only the *Ætherial* (or those Igneous which in Minutes and Motions, are ad-
equat

equat to *Aetherial*) Particles, can Permeate the Metals that the Body is contained in, and consequently for want of the Assistance of the Aerial Expanding Particles, act upon it but weakly, and only carry off the Volatile Watry Particles at first; and after that, if the Fire be continued, and encreased, the less Volatile *Acid* or *Nitrous* Particles next; and after that the *Oil*, every one (separate, which will therefore be without *Flashes*, and consequently without *Flames*: And tho' the Body by this, is not incinerated, yet the mean Particles are so far Evaporated, and the Bond of Unity thereby, so far dissolved, that it leaves it Fragile and easily Pulverizable or Calcin'd, as Distilled *Harts-Horn*, &c.

6thly, If the Body contains no Fluid, or Expansive Particles, as *Glass*; or such only which serve for the bond of Unity, and are so stubbornly united with the Fixt, as in *Gold* and *Silver*, that these Fiery Particles have only Power to force themselves between, and thereby so separate and agitate them as to put them into a State of Fluidity; but does not, or cannot sublime any of them they are said to Melt; and their Particles, thus Separated and Fluid whilst the Fire lasts, will reunite again, and become a Solid Body, as soon as the violence of the Fiery Particles begin to cease, and withdraw themselves, &c.

C H A P. XXIX.

2dly, **T**HAT the *Aerial, Acid, or Nitrous* Particles, as they have a contracting Spring, will Account for all the *Phænomena* of Condensation, and Coldness, Frost, Snow, Ice, &c. has bin already shewed; and therefore the *Flux* of these *Nitrous* Particles to the Poles, thro' the Middle Region of the Air, as has bin shewn in the foregoing *Chapter, Sect. 3d.* will easily be supposed (from what has bin said of their *Frigorific Quality*) to Cause such a Degree of Coldness there, as to Condense the Watry Clouds in those Regions into Ice, and to Cause Hail to descend from thence in our hottest Months. Which likewise confirms the *Hypothesis*, because 'twill be very difficult to assign any other probable Cause for the Coldness of these Regions. But tho' the *Nitrous* Particles are the Cause of *Frost*, &c. as has bin proved, yet the manner of their Action in the time of Freezing, remains yet to be explained.

And before we can do that, we must consider what *Phænomena* precede and accompany Glaciation; which have bin very nicely and curiously observed, and plainly demonstrated by divers Experiments by the *Academy Del Cemento*: Who in their *Essay of Natural Experiments* p. 78. tells us, 'That upon the first Immersion of the Ball, as soon as ever it touched the Freezing mixture, we observed in the Water, in the Neck, a little rising, but very quick, which soon

soon subsiding, it fell in the Neck with a Motion regular enough, and moderate Velocity retiring to the Ball, till arriving at a certain Degree it stop'd for some time, as far as our Eyes could Judge Immoveable. Then by little and little it remounted, but with very slow Motion, and apparently equal; and then of a sudden without any proportionate Acceleration, it flew up with a Furious Spring: At which time, it was impossible to follow it any longer with the Naked Eye, instantaneously running thro' the Decades of Degrees. And as this Fury began of a sudden, so of a sudden it ceased, changing from that great swiftness to a Movement, tho' very fast, yet incomparably less swift than the precedent; and with this it continued to Rise, most commonly till it ran over the Top of the Neck: And all the while these things happened, were observed several little Corpuscles of Air, or some other more subtle Body to arise, and pass thro' the Water, sometimes in a greater, sometimes in a less proportion. This separation was not visible, till the Water began to receive an intense Degree of Cold; as if the Force of the Cold, had the Faculty of Secreting such a matter from the Water. After this, we were willing to see, if these Alterations kept a kind of equality or proportion with each other; wherefore we repeated the Freezings, scarce one Ice being dissolved, but we set it again to Freeze: Yet because they did not still every time Rise to the same Marks, or Degrees in the Neck, we began to imagine their was no fixt Period: For which it seemed we had some reason. At last it happened that in often repeating these Experiments, we by chance let the Water in the

U Bolt-head

Bolt-head Freeze in the Neck first, (of which
 we spoke in the *Fourth Experiment of Freezing*)
 and so broke one Vessel. Whereupon we were
 forc'd to make another, this we Blew less than
 the former, that the Cold might soon infi-
 nuate thro' all the Water ; we also made the
 Neck longer, to the Height of $45 \frac{1}{2}$ Inches,
 that it should not run over. This we filled to
 160 Degrees, and set it to Freeze in Ice, very
 diligently heeding it, we found at first, that all
 the Accidents of Subsiding, Rising, Resting,
 Remounting, Swiftly Running up, and Stoop-
 ing again, were the very same ; (*i. e.*) hap-
 pened always, when the level of the Water was
 at the same Mark or Degree in the Neck :
 For upon puting it in the Ice, we observed, it
 was reduced to the same Degree, as in the for-
 mer Tryal, that is to say, at the same Tempe-
 rament of Heat and Cold ; taking the whole
 Instrument for a nice *Thermometer*, by reason
 of the largeness of the Ball, and proportion of
 the Ball, and proportion of the Neck, being
 satisfied so far ; we proceeded to find the Exact
 Time of Freezing : And to obtain this, we took
 the Ball out of the Mixture often, yet as often
 as we tryed it, we were never so successful, as
 to find the first small Veins or *Stiria* of Ice,
 but 'twas either all fluid or all over Frozen ;
 whence it was easie to gather that the Act of
 Glaciation must be very quick. We let it stand
 therefore, and be reduced to its first Mark, and
 placed it again in the Mixture, and took no-
 tice of the Degrees whereat it begun to mount
 so swiftly ; and half a Degree before it came
 to it, we took it out, and very heedfully re-
 garding it with the Eye, the Water in the Ball
 thro' the transparency of the Vessel, was easily
 discerned.

discerned, to be yet all Fluid; but the before received Impression of Cold still Acting (tho' it was just arrived at the Point, with a swiftness indiscernible by the Eye, and therefore scarce to be conceived, forced the Water thro' the Neck, and in an Instant took away all Transparency from the Ball, and changed its Fluidity into Ice. We were satisfied by often repeating the Experiment, that 'twas just as we have related it, that there was a constant Rise upon Immersion, Abatement, Rest, Remounting, and Spring upon Glaciation, which are set forth in *Tables*, upon the Freezing of several Sorts of Waters thus,

In the Freezing of Spring-Water.

		<i>difference.</i>
State Natural	142	1 $\frac{1}{2}$
Rise upon Immersion	143 $\frac{1}{2}$	23 $\frac{1}{2}$
Abatement	120	
Rest	120	10
Remounting	130	36
Spring upon Glaciation.	166	

In the Freezing of Simple Rose-Water, Stilled in a Cold Still.

		<i>difference.</i>
State Natural	140 $\frac{1}{2}$	2 $\frac{1}{2}$
Rise upon Immersion	143	27
Abatement	116	
Rest	116	11
Remounting	127	67
Spring upon Glaciation	194	

*In the Freezing of Myrtle-Flower-Water, as it
stood in the Tube in a*

		<i>difference.</i>
State Natural	145 $\frac{1}{2}$	
Rise upon Immersion	147	1 $\frac{1}{2}$
Abatement	109	38
Rest	209	
Remounting	125	16
Spring upon Glaciation.	230	105

*In the Freezing of Orange-Flower-Water, as it
stood in the Tube in a*

		<i>difference.</i>
State Natural	137	
Rise upon Immersion	139	2
Abatement	111	28
Rest	111	
Remounting	127	16
Spring of Glaciation.	250	123

Freezing of Snow Water.

		<i>difference.</i>
State Natural	136 $\frac{1}{2}$	
Rise upon Immersion	139	2 $\frac{1}{2}$
Abatement	111	28
Rest	111	
Remounting	116 $\frac{1}{2}$	5 $\frac{1}{2}$

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Freezing of Stilled Cinamon Water.

		<i>difference.</i>
State Natural	139°	1 ½
Rise upon Immerſion	141	
Abatement	111	
Reſt	111	29 ½
Remounting	120 ½	
		9 ½

‘ This Water Riſing with a very flow Motion from the State of Reſt, to 120 ½ Degrees, inſtead of Springing up as it then uſes to do, it only mounted with a quicker pace, which perceiving, we immediately took the Veſſel out of the Mixture, and found the Water ſhot into a very tender Ice, which melted as ſoon as ever it was ſenſible of the Air. The Snow-Water roſe from the State of Reſt as this did, and its Ice was unequal, broken, and ſhot into Irregular Veins.

From all which *Experiments*, ’tis evident, That there is a conſtant Series of *Phænomena* ſucceſſively preceding Glaciation, upon the application of the Frigorific Mixture, (*viz.*) a Riſing, Subſiding, Reſting, Remounting, and a ſudden Spring, or hurry of them, before Glaciation, which afterwards gradually decreases.

All which, I conceive proceed from the Action of the *Nitrous* Particles, as they gradually pervade and affect the Glaſs, and its contents. *First*, There is a ſmall Riſing, rarely exceeding two Degrees, upon the firſt Immerſion of the Ball into the Frigorific Mixture, and on the contrary, they likewise obſerve, *pag.* 104. that upon the Immerging the Ball into hot Water, the Fluids in the Tube ſenſibly ſubſide. This they

say (pag. 105) proceeds from the Fixing of several Volatile Particles of Fire, evaporated from the hot Water) into the External Pores of the Glass, which are as so many Wedges forcing, and separating the Parts thereof, must necessarily distend and enlarge the internal capacity thereof; till they find a way thro' the hidden passages of the Glass, to the Liquor therein contained. That on the other side, Cold binding up, and contracting those Pores of the Glass, makes the Vessel become too scanty for the Bulk of Water in it, before that bulk of Water, yet unaffected by the cold Contracts likewise. In fine, that the Vessel being first sensible of Cold or Heat, by shrinking or enlarging it self also first, is the true Cause of that *Phanemenon*, of the Rise or Fall, as it becomes more strait or large to the contained Liquors, yet not vitiated by the quality of the Ambient. This Opinion is rendred more probable by the following Experiment, *ibid.*

We included in a Globe of Glass filled with Water, several small Bubbles of coloured Glass, Empty, and sealed Hermetically: These were all near the Specific Gravity of the Water, by means of the Air they had in them, whence the Floaters upon the top of the Water, upon the least breath of Warmth sunk down; and those at the Bottom upon any accession of Cold mounted upwards. Having this Instrument in the Air, and suffering the Bubbles to rest, we began to approach to it underneath a Pan of Water heated, and after that of cold Water mixt with Ice well broken, and tho' upon the application of these different Ambients, we observed the same effects in the level, of Raising it self upon the touch of Cold, and subsiding upon

upon that of the Hot Water yet we could not find when the Water seemed Condensed, and Contracted, that many of them at the bottom Rose up, nor when the Water seemed Rarified and Enlarged, any of the Floaters sunk to the bottom. But these were observed to Fall, and those were observed to Rise, when the Water after its Abatement upon the first Impression of Heat began to rise again; and when after its Rising upon the Impression of Cold, it began to subside again. An Argument to insinuate that the Water, and so any other Fluids in this first Motion, do not really move themselves, but only obey the alteration of the Vessels they are contained in.

This Argument very conclusive in its self, they support with many more, in which they fairly prove, That not only Glass, but Mettals are capable of being Dilated or Contracted by Heat or Cold: So that they leave it past dispute, that, that sudden Rising or Subsiding, upon the application of Heat or Cold, proceeds from the shrinking or dilating of the Glass, (see them there at large.)

2dly. As this contracting or shrinking of the Glass, causes but a very small Rising, so it continues but a very short time; for as the *Nitrous* Particles proceed into the Water, so they wrap up or condense the *Aerial* Particles contained in its Pores, upon which the whole bulk of *Watry* Particles, contained in the Ball close nearer together, and are contained in less room: Upon which that in the Tube, will not only Descend to the place from whence it arose, but many Degrees lower, where 'twill be for some time at a stand: but then as the *Nitrous* Particles proceed farther, they will begin to attack the *Spirituos*, and *Ætherial* Particles contained in the Water;

which being put to flight by the *Nitrous*, will be collected into a Body in the Centre of the Glass (as their manner is, as has bin already shewed in Liquors in the hard Frost,) that being in the remote Place, when they are set upon all manner of ways. Being in this Posture, the *Nitrous* Particles at first but weakly attacking them, by a weak *Luftation*; will be Repulsed by them; but every *Luftation* being accompanied with an Expansion, will cause that Gradual Remounting again, till after two or three Repulses, they returned with redoubled forces, and make a furious onser on all Sides; which Causes so violent a *Luftation* betwixt them, and so great an Expansion, as to cause the Water in the Tube, in a Moment, to run thro' all the Degrees to the Top.

In this *Luftation*, the contracted Spring of the *Aqueous*, and *Nitrous* Particles, will be stretched and expanded, and both these and the *Spirituons* in the Contest, will be so mutually Twisted and Embarrassed with each other, that they will at the same time, lose their Fluidity and Perspicuity, and be context or combined into the Consistence and Firmness of *Ice*. They lose their Fluidity, which depends upon the Volubility of Globular Particles at liberty, because now being stretched out, their Form is altered: They lose their Perspicuity, because they now being mutually Twisted, Plated or Embarrassed with each other, the Rectitude of their Pores is perverted; and because the same Particles take up more room, being compacted into *Ice*, thus stretched and expanded; therefore a piece of *Ice* is proportionably lighter than an equal Bulk of Water.

First, That there are such *Spirituos*, and *Ætherial* Particles in the Pores of Water, has bin already proved. *2dly*, That there should be a Luſtation upon the admiſſion of *Nitrous* Particles with theſe, is a neceſſary conſequence from their Texture. *3dly* the Violence of this Luſtation, is ſhewed by the Force of their Expansion in the time of *Glaciation*.

And that *Glaciation* proceeds from this Luſtation with the *Spirituos* Particles ſeems credible: *First*, becauſe a ſmall quantity of *Aqua Vita* ſprinkled upon the Freezing Mixture, wonderfully intends its Force, as the *Academy del Cemen- to*, obſerve *Pag. 76. and 100.*

2dly. Becaue thoſe Waters that may be ſuppoſed to abound more with theſe *Spirituos* Particles, Freeze quicker, harder, and firmer, and their Ice is more Expanded and Lighter, as is ma- niſeſt, from the Experiments made with the *Orange* and *Myrtle-Flower-Water*, which we may judge by their Fragrant Smells, moſt to abound with theſe *Spirituos* and *Ætherial* Particles; and therefore to make a ſtronger Luſtation, and greater Expansion: From whence we may expect to find the Particles more firmly Twiſted, Entang- led, and Compacted among themſelves, and conſequentially a Harder and Firmer Ice. And accordingly we find in the Tables, that the Spring upon *Glaciation* in *Orange-Flower Water*, is three times as ſtrong as that of *Spring-Water*; and it may be ſuppoſed there is much more difference betwixt it and *Snow-Water*. And accordingly *Pag. 89.* they Note that the Spring upon *Gla- ciation* is more or leſs High, as likewise more or leſs Swift, in different Fluids: And it ſeems to be higher and ſwifter in thoſe that Freeze ſtronger. And *Pag. 90* they Note, that of
theſe

these Artificial Freezings some were more Weak and Tender, as the Ice of *Cinamon Water*, and that of *Rose-Water*; others more Firm and Hard, as that of *Orange* and *Myrtle-Flower-Waters*, than which we found no Liquors so hardned at the first instantaneous Freezing.

2dly, That the *Spirituos* Particles are collected in the Centre, besides what has bin already said, of Liquors in the hard Frost appears by the 2d. *Experiment Del Cemento*, Pag. 73. where they say,

Finding that the Force of Freezing far surpassed the Resistance of this our first Instrument, we thought of making a Ball of Cast Silver, of the thickness of a Crown Piece, and of an Oval Figure, to open in the middle with a Screw, and with a Top Screwed on at the end of the Neck; then shutting this Vessel, and Screwing fast the middle Screw with a Vize, we filled it with Water at the Neck, and Screwed on the little Cover, and set it in a Mixture of Salt and Ice to Freeze, and in a little while taking it out, we found it perfectly sound, and whole; opening it in the middle, we took out a Shell of Ice, but it was very Tender, and less Transparent than usual, and perchance more Dense and Close; for being put into Water, it not did seem to buoy up so well, but rather (as all thought) dived towards the bottom, in the middle was a Cavity as big as a large *Almond* without a Shell. This Experiment was repeated after by us, with the same success.

To this Cavity in the Middle, it may be rationally supposed, the *Spirituos* and *Ætherial* Particles had their recourse, and being there confined, so that they could not expand in the time of Luëtation forced thro' the Screw, (as will appear

pear by the next Experiment,) and therefore left the Ice more Tender and Heavie than ordinary, because its Particles were not sufficiently Dilated and Combined by a Luſtation with theſe Particles. The 3d Experiment which confirms this, is as follows.

‘ There were ſome that wondered at this unexpected Accident, ſeeming at firſt to contradict, not only the Opinion of *Galileo*, but what is more, to be inconſiſtent with it ſelf; ſeeing tho’ this Ice appeared Condensed and Heavie, in reſpect of that made by the Cold of the Air, without any Art; yet it muſt neceſſarily be Lighter than Water, becauſe it in ſome meaſure ſtill ſwarm thereon; and ſo much the leſs could they ſatiffie themſelves, as they ſaw the Vacuity always in the middle of the Water congealed. Whence it ſeemed neceſſary to conclude, that the Water, which Fluid, ſufficed to fill the Ball; being Frozen, withdrew it ſelf, into ſo much a leſs ſpace, as the above mentioned Vacuity; from ſo manifeſt an inconvenience, they were inclinable to think there muſt be ſome Fallacy; and therefore ſet themſelves to obſerve very nicely the whole progreſs of the Experiment. So taking the Veſſel very often out of the Freezing Mixture, and carefully viewing it on all ſides, they perceived an almoſt inſenſible Boyling, and Bubbling out at the middle Screw, from time to time; a manifeſt Sign that the Water (ſo great is the Force of its Rariſaction) crept thro’ the Spiral paſſages of the Screw; upon this, the Screw being Waxed, and the Ball again filled, it was ſet in the Ice and Salt to Freez, and tho’ ’twas many times taken out, there was never obſerved any Bubling, or any Hiſſing heard as before. But after the
Freezing

Freezing was done, upon the taking it out of the Mixture, the Vessel was open on one side of the Middle Screw, the rarifying Power of Freezing being great enough to Force the Screw: The Experiment being often repeated, had still the same Effect. And being again tryed in a Ball of Brass, with a Screw of twice as many Threads as the Silver one had, it still shewed the same Trick: Which confirms what is said above.

3dly, That there is a Luftation, and Violent Commotion in the time of Glaciation, is visible to the naked Eye; for Pag. 97. they say, ' All the while these things happened, were observed several little Corpuscles of Air, or some other more subtle Body to arise, and pass thro' the Water sometimes in a greater, sometimes in a less proportion. This separation was not visible, till the Water began to receive an intense Degree of Cold: as if the Force of the Cold had the Faculty of secreting such a Matter from the Water: Which remarkably favours our Hypothesis.

4thly, This Luftation is performed with extraordinary Celerity; for Pag. 80. they say, when it was just arrived at the Point, with a swiftness indiscernible by the Eye, and therefore scarce to be conceived, forced the Water thro' the Neck, and in an Instant took away all Transparency from the Ball, and changed its Fluidity into Ice.

5thly, With an unimaginable Force, or else they could not stretch the Mettal, they were contained in wider, as in the 6th. Experiment p. 76. *Del Cemento*, where they say, ' The last Experiment was made with a Ball of fine Gold, of the size represented in the Figure, this having undergone

undergone many Freezings without any sensible crack, caused at first no little Wonder ; but at last observing, that whereas the Ball before Freezing, was stated so, that it would stand upon the bottom : When it was taken out of the Freezing Mixture, it would not stand upright ; every one was well satisfied whence it happened : and because it seemed to us perfectly Spherical, to be the better assured thereof, whether it would remain of its first size, or whether it would stretch bigger ; we made a Ring of Brass, exactly fitted to the Vessel's greatest Circle : All along in Freezing, by examining it with this Ring, we still found it grow bigger and bigger ; that pure Mettal, by reason of its softness and plianthness, still dilating and stretching it self, as in the former Experiments made in courser Mettals, it always broke thro'.

Which shews 7thly, that there is an alteration in the Figure of the Watry Particles ; for if they had continued in that Globular form, they were in the Fluid, they would have rather have forced thro' the Pores of the Mettal, as in the 3d. Experiment, about the *Compression of Water*, Pag. 117. *Del Cemento*,) that either have stretched out the Mettal wider, or have broke thro' it, which alteration of Figure can scarce be conceived to be effected, without some Intestine contending Force.

From whence it seems reasonable to conclude, that since there is such a Collection of *Spirituos* Particles in the Centre, such a violent Luctation betwixt them and the *Nitrous* ; and upon that an Expansion and an Alteration of Figure, enacted with so much Force and Celerity in the time of Glaciation, that the manner of Freezing is as above supposed.

I was surprized many Years since with a *Phænomenon* of this Sort : I went into a Cloſſet where there were many Bottles of Diſtilled Waters, and all of them Froze but one, which remained Fluid, and being curious to know what it was, I plucked out the Cork ; upon which I ſaw a ſtrange Commotion of the Watry Particles, which immediately terminated in Solid Ice, the whole bulk of Water being throly Froze, whilſt I held it in my Hand, I preſume in leſs than half a Minute's time. I could not certainly diſcover what Water it was, but I gueſt it to be *Plantane-Water*.

Note, that when I ſay, that Water in which are moſt *Spirituſous* Particles will Freeze hardeſt, muſt be underſtood to ſuch a certain Degree, that they may be overpowred by the Nitrous ; for where they are too numerous as in *Spirit of Wine*, they keep the *Nitrous* at a diſtance, ſo that they have no power to Aſt upon them, or any way to affect them, any otherwiſe than by condensing the Aerial Particles in their Pores. And for this Reaſon, Wines and other Strong Liquors, that abound with theſe Particles, are never throwly Froze ; and if at all, 'tis only in the extreme Parts near the Sides, as appears by the ſeveral Experiments made on *Florence-Wine*, *Muſcadine*, *Cinamon-Water*, &c. by the *Academy Del Cemento*, Pag 91, 92. &c.

C H A P. XXX.

3dly, **T**HE *Aerial* Particles, properly so called, as they have an *Elastic* Expansive Spring, and are more Dense than the *Ætherial*, will Account *First*, for all the *Phænomena* of *Sound*, *Eccho*, &c. 2dly, As 'tis in a Violent Comprest Condition; it will Account for the continuation of all the *Motions of Inanimate Bodies*, and in a great Measure of *Animate Bodies*. 3dly, For *Hydraulics*, and particularly for the *Springs* on the Sides, and Tops of Hills.

First, *Sound* proceeds from an Impulse or Brisk commotion of these *Aerial* Particles, which by reason of their great Elasticity, are darted (like the *Ætherial* Particles from the Body of the Sun) circularly, or every way to a distance Proportionable to the Stroak; which being continued to the Ear, are collected by its External cavity, and directed to that delicate fine Membrane called a *Drum*, upon which it beats, which continues the Impulse to the String behind it, in which the *Hammer* is fastened; this moves the *Hammer* to beat upon the *Anvil*; which subtilizes the Internal Air, and drives it by the Winding of the *Labyrinth*, into the *Spiral Cochlea*, where it presses upon the Nerve, and causes that Alteration in the Sentient, which we call *Sound*.

The Internal Air being driven from a wide Cavity to a narrower, is the Reason that the least Impression of the External Air upon the *Drum*, is communicated to the *Auditory Nerve*; and the

the extreame fineness of the *Timpanum*, is the Cause, that the least Agitation of the Air, makes an Impression upon it, as the easie Motion of our Breath, modelled by the Tongue, Lips, &c. in Speaking, each Stop and Turn of which is conveyed distinctly to the Ear; and by reason of the great Volubility of the *Aerial* Particles, is easily distinguished by it at a great distance; nay, these *Aerial* Particles (by reason of their Elasticity, are so very apt to fly, that the Sound of a Trumpet, or what is the same thing, the weak Impulse of our Breath thro' the Hollow of a Trumpet, or the Stroak upon a Bell, will drive them to some Miles distance, so as to affect the Ear.

That the *Sound*, proceeds from the Stroak of these Particles (in the Air,) put in Motion, by an Impulse at some Miles distance, as from a Bell, &c. is evident from these Experiments of the Immortal *Boyle*.

He says, he suspended a Watch, which had an *Alarum* belonging to it, by a piece of Thread, which was tyed to a Glass Button purposely blown in the inside of the Receiver, which was made of an intire Piece, so that it was less subject to break, we ordered the Watch so, that the *Alarum* should begin to go, by the time that we were ready to make our Observations; at which time one held his Ear near enough to the Top of the *Receiver*, perceived that when the Air was wholly Exhausted, the Sound of the *Alarum* was scarce at all discernible, but became much louder, as the Air was gradually let in; He says the same of a Piece of Steel, that he made strike upon a Bell in an Exhausted Receiver.

By which 'tis plain, *First*, That *Sound* is produced by those Particles that are capable of being Exhausted out of the Receiver, otherwise it would be propagated in the Receiver when exhausted. *2dly*. That 'tis the *Aerial* Particles (properly so called) that by Expanding themselves, where the Pressure of the Atmosphere is taken off, that are thus exhausted, has bin proved before, and consequently 'tis these, that cause that Affection, which we call *Sound*. *Lastly*, that they are put in Motion, is evident from this; that a Volley of Shot, or the Firing of great Guns, at a due distance, tho' far off, will not only break Glass Windows, shake Houses, but will make the Body totter, by altering (by their Impulse) the *Æquilibrium* of the Circumvolving Air, at the same Instant that we Hear; and consequently that they must be drove by the first Impulse, thro' all that distance from it to the Ear; which will succeed, tho' propagated from an Impulse many Leagues at Sea, and therefore cannot proceed from the shaking of the Earth, as some may suppose.

If these Particles in their Progression, met with any Solid Body of a Flat or Concave Figure, by which they are reverberated back again in the same way they came, (as a Ball from a Racket, or the Solar Rays that fall Perpendicular from a Looking-Glass,) to the Ear as they fell upon it at first, they will Affect it in the same manner, and consequently repeat the same Word or Sound, as they did before, which we call *Eccho*.

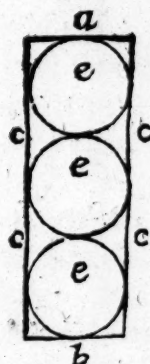
If there is nothing to oppose the Motion of these Particles, they proceed on, as far as the Imprest Motion continues, and cause *Sound*, but still weaker and weaker, as 'tis farther from the first Impulse; and this is the Reason that Rocks,

Caves, Buildings, Trees, &c. are always near the place where there is an *Eccho*.

C H A P. XXXI.

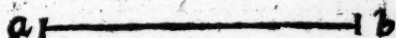
2dly, **T**HAT the Pressure of the Air, by reason of the incumbent Particles, and their own Springs, being confined to such a Space, is equal to the Weight of a Pillar of *Mercury* of 30 Inches long, has bin proved before; and therefore, 2dly, it will force a Globe, or Ball of any Matter that is not 120 times Heavier than *Mercury*, any way where there is nothing to hinder it, or where the Pressure of the Atmosphere is taken off, as we see in the *Torricellian Experiment*, where the Pressure of the External Atmosphere, will with Violence Force *Mercury* to ascend 30 Inches high in a Tube (suppose) of a Quarter of an Inch Diameter, in which there is no Air to hinder it, it being forced out by the *Mercury* it was before filled with.

Which *Mercurial* Pillar will exceed the Weight of 120 Globules of the same Matter, as much as the Weight of the same Matter in the Figure of a Cylinder, will exceed a Globe of the same Diameter of the Cavity of the Tube or Cylinder; as in the Fig. suppose *ab*, a Cylinder or Glass Tube, *eee* Globules of the same Weight as so much *Mercury*; It is plain that those three Globules will not be so heavy, as a Pillar or Cylinder of *Mercury* of the same length; because there are void Spaces betwixt each Globule, as *cc* which are filled up in the Pillar; and because there is no
Body



Body heavier than *Gold*, that we know of, which exceeds not *Mercury* above a $\frac{1}{3}$ in Weight, 'tis manifest that the Pressure of the Atmosphere that is near 120 times heavier than it, will carry a Ball of any Matter whatsoever any way, (either up Perpendicular, or Oblique, or Parallel to the Horizon, where the Spring or Pressure of these Aerial Particles are taken off.

2dly, 'Tis evident from what has bin said before, under the Article of *Sound*, that a small Impulse will drive these *Aerial* Particles to a great distance, as from *a* to *b*, and consequently take off their Resisting Force from *a*, the Place



where they met the Impulse, they being impelled towards *b*, so that the Space betwixt *a* and *b*, remains empty; and then if *a*, or that Body that gave the Impulse be free, (*i. e.*) not fixt to the Earth or otherwise withheld, as an Arrow from a Bow, or Bullet from a Gun; the Pressure of of the Atmosphere (that is near 120 times greater than the Weight of *Gold*) behind the Body *a*,
X 2 will

will carry it in the same Line also towards *b*, there being nothing to hinder it that way, till the Motion of the Particles impelled towards *b* ceases, and reassume their Impulsive Force from *b* towards *a*, which will make an Æquilibrium to those behind *a*, and consequently cause a Cessation of its Motion, at a distance nearer or farther off proportionable to the first Impulse.

These *Aerial* Particles seem to be put in Motion or impelled chiefly from Five Causes.

First, From the sudden Restitution of a Spring to its wonted Station, as in the first Instance.

Secondly, From the Explosion that proceeds from the sudden Rarification of a Body, as in the second Instance: for *Gunpowder* being thus suddenly Rarified, it requires more room; to obtain which, it violently Impells the Bullet before it, and the Bullet the Aerial Particles; and the longer the Force of the Rarified Body presses upon the Bullet, the more violently it Affects it: which therefore drives the Aerial Particles with more force before it, to a greater distance: After which, the Bullet is likewise carried by the same Particles behind it. Which is the Reason that a Long Gun Shoots farther than a Short One.

Thirdly, From such Rarification, or Compression which Causes Wind; which has bin Accounted for before.

Fourthly, From the Motion of the Spirits, like a Wind, into the Muscles of an Animal; by which the Nervous Fibres in their Extremities are contracted, and by circumleging the Capillary Veines and Arteries, the Motion of the Blood in them is hindered, and the Fleshly Fibres in the Belly of the Muscle thereby swelled; upon which the Nervous Fibres, (like a Leaver rests) and

and raise the Limb more forcible this way or that. That Muscular Motion is performed after this manner, seems probable; *First*, Because the Nerves accompany the Blood Vessels at their ingress into the Muscles, and are distributed to all their Carnous Fibres.

2dly. Because the Muscles in its Action swells, and the thickness ensuing upon the Swelling is always confined to the *Venter*, and generally appears on the out side.

3dly, Because it, and its Blood Vessels, being distended, are hard to the Touch, and its Nerves are lessened and hard, being more extended.

4thly, Because in time of Action 'tis redder than usual, which shews 'tis more filled with Blood than ordinary.

5thly, Because if a Ligature be made upon the descending Trunk of the *Aorta* of a Living Creature, (the Blood being stoped thereby) all the Inferior Parts are deprived of Motion; but if that Ligature be taken off, and the Blood admitted again to flow into the Muscles, they will again exert their Motions: Which shews that the filling of the Blood Vessels in the Muscles is necessary to Motion, as the abovementioned Redness shews that they are filled. And this will not succeed by being filled with Blood only, but also with any other Fluid: for tho' the Ligature be continued upon the descending Branch of the *Aorta*, and the inferior parts remain Motionless thereby, yet if you inject Water only into the *Crural Artery*, suppose of a Dog, the Legs will again renew their Contractions, which the Nervous Fibres could not perform before, (tho' they have always a strong Tension, as is plain by their great Contraction being Cut,) because they want a *Fulcrum* to rest upon. Which

at the same time (besides the Inflation of the Animal Spirits,) causes a greater and stronger Tension in the Nervous Fibres, and a more convenient Position for Motion, as they pass over the Flethy Fibres, in the *Venter* of the Muscle thus distended.

Lastly, the Muscles in general are most Regularly Formed and Situated, to be thus moved by this *Mechanism*. If the Muscles moves a Limb, as suppose a Leg, with so much Force, as to impel the Air before it, the Protruding Atmospheric Particles behind it, will drive it forwards; which if it be continued alternatly from one Leg to another, causes Progressive Motion.

If all the Muscles exert their Power together, they will impel the Air with so much Force, from before you, that the Protrusion of the Atmosphere will bear you from the Ground, and carry you along also, (as in Leaping,) and farther as the Impulse you make upon the Air is greater: this is confirmed by two *Grasshoppers*, which continued for a Quarter of an Hour very lively in *Vacuo*, continually moving up and down, tho' not Leaping; but upon the admission of the Air they Leaped away, *Experiments del Cemento*, Pag. 62. There is the same Account of a *Frog* that Leaped as soon as the Air was admitted Pag. 64. Which is the Cause that you can Leap farther, when you run before you Leap, or at a Running Leap, than at a standing; because by your Running, the Air is impelled before you, in the same way you are to Leap, so that when you Leap, you have not the same Force to Resist you before, and a greater behind to drive you forward (the Air encreasing its Force behind, as you more violently impel that before,) which therefore carries you farther.

If a Muscle draws a Limb back, (as suppose the Arm,) and then forces it violently forwards, (or the contrary) against another Body, it makes the motion of *Percussion*, which is stronger, when the Arm or Hand, especially with any Thing in it, takes a greater Swing. *First*, Because then the Muscular Force is longer continued, and still adds to its Weight. *2dly*, Because its Celerity encreases (in Proportion to the Rectitude of its Descent, as the Motion of a Grave Body in Descending encreases. So that the Weight of a Pillar of *Mercury* 30 Inches long, of the bigness of the Beetle, accelerated by the Spring of the Air, and Strength of the Muscle, is added to the Beetle, when it fall upon the Wedge, at the same time that the Resistance of the Atmospherical Particles, is taken off by those that are drove before the Beetle, which Weight falling upon the Wedge, at that time when the Pressure of the Atmosphere is taken off, will drive it a little, which little by reason of its Figure, it will hold, till by repeated strokes, it rends that to pieces, that a Dead Weight of many Tuns would not do.

The *Fifth* Cause of Motion is *Gravitation*; for as the Weight of any Grave Body, exceeds the Weight of the Air, so it being let fall in the Air, will give an Impulse to it, and drive it to such a distance before it, that is proportionable to the Excess of its Weight, to that of the Air's.

And then *2dly*, The impending Air, by reason of its Spring, and the Fullness of the Universe, finding there a free passage, will expand it self and follow it; and by beating upon it, it will add Force to its Weight, which will encrease its Motion as it Descends.

And 3^{dly}, Because the Grave Body naturally Descends, its Motion will be continued, and the Protruding Aerial Particles will find less Resistance from it, as it proceeds farther; and therefore will Affect it more. By which the Force of the Grave Body, upon those Atmospheric Particles it falls upon, will be Augmented, and its Motion Accelerated, till it comes to the Earth, in a Proportion as the Encrease of Odd Numbers from Unity, (as is observed,) that is to say, 1st Second of Time, it goes one Yard, in 2^d. Second of time, it will go three Yards, in the 3^d Fröe, the 4th. Seven, and so on.

And 4^{thly}, Because all the lighter Particles of Matter were impelled from the Centre in the Chaos, by the subsiding Pressure of the Heavier, (as has bin shewed,) and are Still kept at a distance by those more Grave they lie upon: In this Condition they are in a State of Force, and therefore will have a Natural Tendency to the Place from whence they came; which Tendency is the Cause of *Gravitation*, the which will be greater as 'tis more Dense, and that is more Dense, that contains more Matter in less Space, and has no (or a less Expansive) Spring: As suppose *a*, a Solid Ball of Iron, *b* the same beat out in manner



a ●

of a Watch Spring or Wire, and wound up in a Ball; its plain that *b*, taking up ten times the space of *a*, and yet no heavier than *a*, would be abundantly lighter than it, in a proportion to

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its Bulk, supposing the Medium to be the same; and if several such Balls of Iron, as *a*, were let fall upon *b*, they would all sink down under it, and raise it up higher, and yet *b*, would have a Tendency to the Place from whence they raised it, and a greater, as 'tis closer wound up, or approached nearer to the Solidity of *a*; because then it would make a greater Resistance to the Medium.

5thly, Because a less Power must give way to a greater; therefore much Matter Concentrated in little Space, will Force its way thro' that, where there is little Fluid Matter in much Space, as a Ball of the same Solidity of *a*, and bigness of *b* justling against *b*, would force it to recede rather than the contrary. From whence it follows, that Dense Matter Weighs more in, or has greater Power to Force its passage thro' a Rare Medium than thro' a Dense: And this is found to be Experimentally true, because a Grave Body Weighs more in Air than Water, Light Bodies Descend as fast in *Vacuo*, as Heavy Bodies do in the open Air, and all Bodies proportionally more, in a more Rarified Air than in a Denfer, as appears by that Observation, that a *Pendulum* of a Clock which beats *Seconds* must be Shorter towards the *Æquator*, where the Air is more Rarified, than in Places distant from it. For as the Radius or *Pendulum* is longer, so a Weight at the end of it is Heavier, and therefore Resist the Motive Power of the Clock, with Greater Force, which makes it go slower. Now if the Weight in Rarer Medium, as near the Equator at the end of a shorter Radius or *Pendulum*, Resists the Motive Power of of a Clock, with as much Force as at the end of a longer *Pendulum* in a Denfer Medium, or more distant from the Equator, it follows, that the Weight

Weight is Heavier near the Equator, than at a greater distance ; because it makes an Equilibrium to the Motive Power sooner. Which perhaps would be better understood if it were put thus :

Every Body will continue in that State, or Place of Rest in which it is, unless it be made to Change that State or Place, by some Foreign Force Imprest upon it ; but if that Force be removed, the same Cause that made it Rest, in its former Place will reduce it into the same State or Place again. 2dly, If any *Agent* as *a*, produce an *Effect* as *e*, then an *Agent* *2a*, will produce an *Effect* *2e*, and *3a*, will produce *3e*, &c. and therefore if a greater *Quantity of Matter*, contained in the same, or less *Space*, be the Force that makes a lesser *Quantity of Matter*, taking up as much or a greater *Space*, give way to it and ascend (as has bin proved ;) a Body will Descend as it has more or less Matter in it, and consequently the Unequal *Quantity of Matter*, is the Cause of the Unequal *Gravitation*, or Descent of Bodies ; this if considered, with the manner how the Particles separated from the *Chaos*, will be very plain.

And 6thly, All Grave Bodies when they Descend, will tend the nighest way to the Centre, that is in a Right perpendicular Line ; because if they Move in any other Way, they Move in a Way different from the Place to which they Tend ; and therefore when they recede from a Perpendicular Line, it is done by a Force foreign to themselves : and the farther they recede from that Line, the greater Force will be required to make them do so.

And upon this, with what has bin said in Percussion, depends all the Phenomena of the Me-

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chanic Engines, (viz.) the *Libra Veditis*, *Trochlea*, &c.

To explain which, suppose the Line or Beam ab , in the first Figure, to be a *Ballance*; if the Centre of its Motion or *Fulcrum* be f , the Line d , being always equal to the Line c , it follows that equal Weights at equal Distances, or equal Power and Weight will make an *Equilibrium*.



In the second Figure, the Distance or Radius ai , being double to bi , (and the Arches of Circles being in the same Proportion as their Radii,) it will follow that c , double of d , the Power or Weight in a , must be but half of that in b , to make an *Equilibrium*, and so proportionably in any other Distance.

First, Because the Radius bi , in describing the Arch of the Circle d , (Fig. 2d) varies much more from its right Perpendicular, than the Radius ai does in describing the Line c ; because the bigger the Circle, the nearer is its Arch to the right Line; and therefore a less Force will Cause a Body to go a little out of its way as in this, than is required to make it go farther out of its way as in that.

2dly, The farther the Moving Power or Force is continued, the more that Force is increased, (as has bin shewed above,) and then the Power a , removing thro' the Line c , which is double the length of the Line d , will be doubly encreased.

ed ; so that one Pound Weight at a , will be equal to two at b ,

In like manner, suppose the Line eg , (in Fig. 2d.) to be a *Leaver*, i its *Fulcrum*, one Pound Weight at e , will be equal to two at g , for the same reason.

This being understood, the following Proposition solves all their *Phænomena*. Let a , be the Moving Power or Force, b the Weight or Thing to be Moved, c the Line of Motion wherein the Power moves, d the Line wherein the Weight Moves, then $c : d :: b : a$; that is, *As the Line wherein in the Power Moves, is to Line wherein the Weight Moves, so is the Weight, to the Power.*

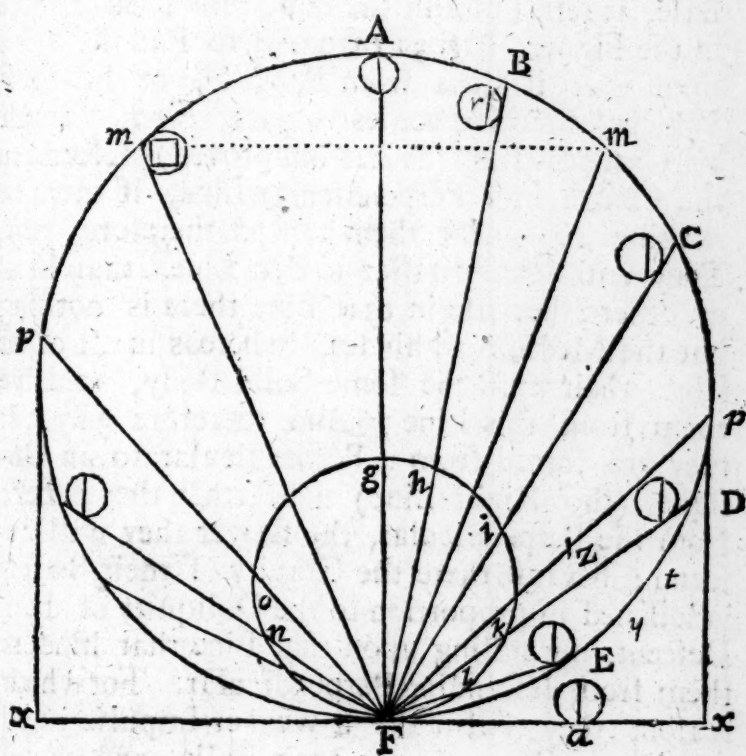
This Proposition will be constantly true in all Machines possible, where the Weight and Force move by continued intermediate Lines, because the Rectangle db , will be always equal to the Rectangle ca , and therefore make an *Equilibrium*.

The Explanation of the rest, as applied to the several Instruments, you may find in Mr. *Ralphson's Appendix* to his *Mathematical Dictionary*.

The *First* and greatest Cause of Motion, I mean that of an *Immaterial Agent*, I have spoken of in another place and shall omit here, it being not subject to the *Laws of Mechanism* ; but that there is such, is most certain, and has bin proved to be the Cause both of Matter and Motion. How an Immaterial Being can Act upon Matter, may be known to be done by His Will, which He has communicated to other inferior Immaterial Beings, or has given them Power to do the like by their Will : But how the Will Operates upon Matter, must be deferred till we converse with Immaterial Beings, and know their Laws.

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The *Second* Cause of Motion, *viz.* that of the Expansion, or Contraction of the Spring in the Active or Mean Particles, that of their Luctation with each other, I omit here, being spoken of before: Under the last of which, that of Fermentation seems to be comprehended, which arises from the Luctation of different and disordered Particles, is continued till the Fixt are Precipitated, and the Active and Fluid equally mixt, as in new Wine, Sider, Ale, &c.



C H A P. XXXII.

BEfore I proceed to the next Head, it may not be amiss to enquire into some other Affections of Motion, as why a Grave Body descends in a Right Line, from any part of a Circle to the Base, it rests upon in the same time; as suppose in the Figure, *Pag.* 317 from *A* to *F* in the same time that it does from *B*, *C*, *D*, or *E*, to *F*. Which I conceive comes to pass, *First*, Because all Grave Bodies, (as has bin proved) descend to the Centre in a Perpendicular Line, if there be nothing to hinder them: And therefore, *2dly*, They will descend faster in that Line, than in any other; because in that Line there is nothing but the Medium to hinder, whereas in all other Lines there must be some Solid Body, to drive them from this Line: And therefore *3dly*, If they are forced from a Perpendicular to an Oblique (tho' Right Line) the farther they deflect from the Perpendicular, the slower they will descend; because there the Gravity of their Bodies is lessened in proportion to the Obliquity of their Descent, by resting upon that Line that hinders them from descending Perpendicular. For which reason, they will make a weaker Impulse upon the Air, in Proportion to their Bulk, and therefore Descend slower. As in the Figure, suppose *A*, *B*, *C*, *D*, *E*, to be Grave Bodies descending to *F*, by the Lines *A F*, *B F*, *C F*, &c. It is plain, *A* will move swiftest, because it presses the Medium before it, with its whole Weight. *B* in
some

some measure resting upon the Line BF , has the Weight of that little segment betwixt its Perpendicular r , and the Line BF , cut off, which in some measure Counter-ballances the other side, and therefore hinders it from Descending with its whole Weight towards F ; but because the side betwixt its Perpendicular r , and the Line AF , exceedingly Preponderates, it will roll towards F , with a Celerity proportional to the Excess of the Weight of that side.

That Segment in the Weight C , being greater, Counter-ballances the other side more, which makes it tend slower towards F ; and D slower than it. For the same reason, the Weight E being divided by its Perpendicular, almost in equal parts, causes it to Move out slowly but towards F ; the Weight a , standing upon a Plane, is divided by its Perpendicular into two equal Parts, and therefore having an equal Inclination both ways stand still.

By this 'tis evident, that as those Grave Bodies are farther from the Perpendicular, so their Weight is gradually lessened, and consequently their Descent is gradually slower, in a proportion equal to the decrease of their Weight, for as the Line is to the perpendicular, so is the Weight of the Body in that Line, to the Weight of the Body in the Perpendicular; as is manifest, because at the same Time that the Weight A in the Perpendicular Line, gradually shortening comes to touch upon the Square of the Circle, the Weight A will be lessened, or divided by the Perpendicular where it touches upon that Line, to its Square as at M ; which shews that they both lessen gradually, and proportionably to each other: and because in an Uniform Figure, the Line and Weight lessen uniformly, they must lessen in the same manner, that is proportionably

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to each other in all parts of the Circle, and then the Body E will be as long in moving to F , as A .

From whence it follows, that the Length of one Line being given to the length of all the rest may be known : For as the Line gF , is to Line AF , so is the Line Fz , to the Line FC .

2dly, The Length and Obliquity of the Line being given, the time that a Grave Body of such a Weight, as suppose Iron, will be in Descending, may be known : For if Iron be the Standard, all other that are Lighter or Heavier, will move faster or slower, allowing for the Encrease of their Celerity as they descend farther ; as for Example, suppose in the lesser Circle $ghikln$, the Line gF , to be 16 Feet, which a Ball of Iron will descend thro' in a Second of Time, then if the Line AF be 64 Feet long, a Ball of Iron will be two Seconds in descending thro' it ; if 154 Feet long, 'twill be three Seconds in moving thro' it : Because Body increase in Celerity, as as they descend, as Odd Numbers from Unity increase. This being known, 'tis easie to know the Time a Globe of Iron, is descending in any other Line ; for as the Time that it Descends thro' Fg , is to the Time that it Descends thro' AF , so is the Time that it Descends thro' kF , to the Time that it Descends thro' FD , which is equal to the Time it descended thro' AF , and so of all the rest.

By the same Rule the Weight of the Body, or the Obliquity of the Line may be known.

Secondly, if the Powers Velocities, Spaces, and Times in these Right Lines be known, the Powers, Velocities, Spaces, and Times in all Curve Lines will be known ; for a Bullet will run thro' the Arch of a Quadrant, in the same
Time

Time, as thro' the Chord of a Quadrant, that is, it will run thro' the Arc pyF , in the very same space of Time, as thro' the Chord pzF , which I prove thus, a Bullet let fall upon the Arc pyF , at p , touches the Perpendicular $p \times$ Horizontally, and therefore falls Perpendicular or with its whole Weight at p , upon the Line pyF ; but its Weight, and consequently its Celerity lessens gradually (to what it would have bin in the Perpendicular) till it comes to y , parallel to z , and therefore the Celerity of its Course betwixt p and y , in the Arc pyF is equal to its Celerity in a Line, that is a Mean betwixt AF , and pF (viz.) MF ; and because at y , it enters the Arc yF , with a Celerity equal to its Celerity in the Line MF , but gradually decreases its Celerity till it comes to F , its Weight and Celerity thro' the Arc yF , will be equal to its Celerity and Weight in a Line that is a Mean betwixt MF , and yF , that is, equal with Celerity in pF ; and therefore in the same Time that the Bullet runs half thro' the Chord pF , viz to z , it will have run half of the Length of the Line MF , thro' the Arc pyF , (viz.) to t . So that in descending from p to y , it will gain the whole difference betwixt the Chord pzF , and the Arc pyF , and half the difference more. But then, because the Weight and Celerity is equal in the Arc yF , and the Chord zF , the Arc yF , being half the difference longer than the Chord zF the Bullet will be longer in running thro' the Arc yF , than thro' the half Chord zF , by the half difference, and therefore the Bullet gaining the difference, and half the difference more in the Arc pyF , whilst the Bullet descends to z , in the Chord pzF , and loosing but half the difference in descending betwixt y and F , the difference will remain gained. And therefore the Bullet will run

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thro the Chord and Arc in equal Time, Which was to be proved.

The difference betwixt the Arc of a Quadrant and its Chord is exactly as 9 to 10; as I found by this means, I took a Quadrant, and after I had drawn a Line, upon a Plane, I set one corner of the Quadrant upon the line, so that one of its square Sides stood Perpendicular, as appeared by the Plummer, the other Horizontal, then I rolled it along the Line till the opposite square Side became perpendicular, where I mark'd out a Line, in length equal to the Arc of the Quadrant, that was divided into 90 Degrees, (beginning at the Lines that terminated the divided Quadrant, because the very extream Corners were a little flated, which might have made some alteration, if I had taken it from them,) and found it to be exactly as 9 to 10: This ought to be done upon Stone, for otherwise the Quadrant is apt to slip.

I conceive the Reason why the Celerity of the Bullet descending thro' the first part of the Arc, (*viz.*) betwixt *p* and *y*, encreases more than it decreases afterwards betwixt *p* and *F* is, because the Impulse on the Air is more than proportional to the decreasing Gravity of the Bullet; for the Impulse on the Air is always from the greater Weight, which therefore hinders the Gravity of the Bullet from decreasing proportionably to the declination of the Curve, because it takes off the Force of the Resisting Air before it; (which is the Reason that the Celerity of Bodies in descending increase, as the Odd numbers from Unity increase, as above.)

At *p*, the Bullet falls with its whole Weight, and therefore drives the Air to a proportionable distance before it, by which the resisting Force of the Air to the Bullet is lessened, which lessens the

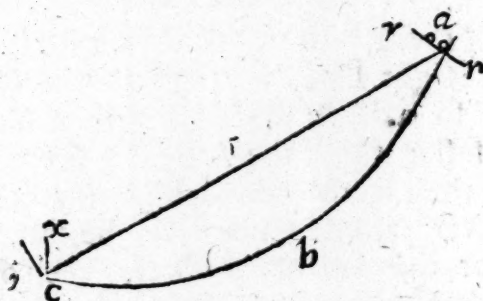
the Decrease of the Gravity of the Bullet, at the next Point ; because as the Weight of the Bullet is lessened by the Declination of the Curve from the Perpendicular, so 'tis encreased by the weaken'd Spring of the Air before it.

From whence it follows, *First*, That if the Time in which a Bullet is descending thro' the Arc of a Quadrant, and its Chord be equal, the Time that a Bullet descends thro' the Arc of any other Curve and its Chord will be equal also ; because as the Arc of any other Curve, differs from the Arc of a Quadrant, so is the difference betwixt its Arc and Chord lessened in respect of the difference betwixt the Chord and Arc of a Quadrant.

2dly, 'Twill follow, that as a Body descending in a Right Line, moves faster in the Perpendicular, so a Body descending in a Curve Line, moves faster thro' the Arc of a Quadrant of a Circle, than thro' the Arc of any other Curve whatsoever, whose Chord has the same Obliquity ; For the Arc of a Circle, being the most capacious Curve, the Arc of any other Curve may be made within it, and then a Body descending thro' the Arc of a Quadrant, must descend swiftest, because it descends thro' a greater Space in the same Time.

To try whether this *Demonstration* were agreeable to Nature, I made the following *Experiment* ; I took a Coopers Hoop about three Inches broad, shaved down to an equal thickness on both sides, and after I had made the *Arc of a Quadrant*, and its Chord with a pair of Compasses upon a Plane, whose Radius was $1\frac{1}{2}$ Inches, I adapted the Hoop exactly to that Arc, and fixt a strait smooth Board of about an Inch and half broad, on one side of it, as its Chord :

This done, I put a Stop at the bottom of the Chord, perpendicular to it, and another on the side of the Hoop or Arc perpendicular to the Base of the Circle upon which it stood, then I made a narrow Hole about two Inches, cross the Hoop at the upper end of the Chord, and thro' it I put a little Ledge, and upon it I placed two Bullets (made in the same Mould, and exactly of the same Weight:) as in the Figure, suppose abc the Arc of a Quadrant, and something more sc the Chord, r the Ledge upon which the Bullet lies, x the Stop perpendicular to the Base, y the Stop perpendicular to the



Chord : the two Bullets being upon the Ledge r , so that when the Ledge was plucked back at n , both fell together, one run along the Chord, and the other by the Arc, and both according to expectation, came to the end at c exactly together.

It being thus evident, both by Reason and Experiment, that a Bullet will descend thro' the Arc of a Circle in the same time as thro' its Chord, I conclude it to be true. And therefore, 3dly, All Demonstration of Motion, thro' a Curve Line, that are made upon this Supposition, that it runs as much slower thro' the last part of the Curve, viz. from b to c , as it does faster in

in the first Part of the Curve, viz. from r to h , than along the Chord rsc , are false. 4thly, That there may be *Concessa in Mathematics* and other Sciences, which like this, seem self evident; yet upon a nicer Examination, may be found to be otherwise, and are the Cause of unexpressible Errors, of which sort *Pardie's* seems to be one; who in the 7th. Book of his *Elements of Geometry*, Pag. 74. says,

'The Demonstrations by which 'tis proved, 'that there are Incommensurable Lines and Magnitudes; shew also that a *Continuum* is not 'composed of Finite Points: for if the Diameter 'as well as the sides of a Square, were composed 'of Finite Points, a Point would Measure both 'the Side and Diameter: For that Point would 'be found a certain Number of Times in the Side, 'and another determinate Number of Times in 'the Diameter, which the preceding Propositions 'prove impossible,

But this I take to be false; for if all Lines consisted of *Indivisible Points*, or Parts so small that they could not be made less, (supposing them all to have an equal capacity to Division,) and Unites stood only for such Points, they must be all of an equal bigness, and then an *Unite*, or one *Indivisible Point*, must Measure all, in all Lines whatsoever. For if you say two Lines may differ by half an *Indivisible Point*, you say an *Indivisible Point* may be halved, which is as much as to say, it may be Indivisible and not Indivisible; if they differ by the whole, the whole will measure it: But the Fallacy of all Arguments of this Nature, lies in this, that they Argue from a Point, or a Division that is not in Nature, to a Point or Division that is; from a *Mathematical Point*, *Cujus nulla est pars*, to a *Phy-*

Physical Point, that has Length, Breadth, and Thickness; and is therefore Solid and Impenetrable, and consequently must take up Space, and then if such, their Arguments would not hold. For those Points that take up Space tho' never so little, yet if they are Infinite must, must take up Infinite Space, for the Space must bear a proportion to their Number, and then they could not be contained within that short Line *A B* (of *Pardie's Lib. 8. Pag. 80.*) where he says ' We plainly see ' that all these terms, tho' they be actually Infinite, cannot make an infinite Length, because ' they will be included in the Line *ab*; but if those Parts the Line *A B* is divided into, be actually Infinite, they must neither be Infinite something nor Infinite nothing, for Infinite something or Quantity cannot be contained in the Line *A B*, and Infinite nothing will not make the least Part of it, so that it must be divided into Parts, that are neither Quantity nor no Quantity. He says in the same Page, that if the Parts be actually Infinite, all taken together will be equal to *AB*, for says he, 'tis plain that if the Diminution be made an Infinite Number of Times, nothing at last will remain: But as plain as 'tis, I take it to be impossible that Something should be Divided into Nothing, for what ever is Divided is, and must be Divided into Parts, but Nothing has no Parts, and therefore if it be Divided into Nothing it must be Divided into Parts and no Parts.

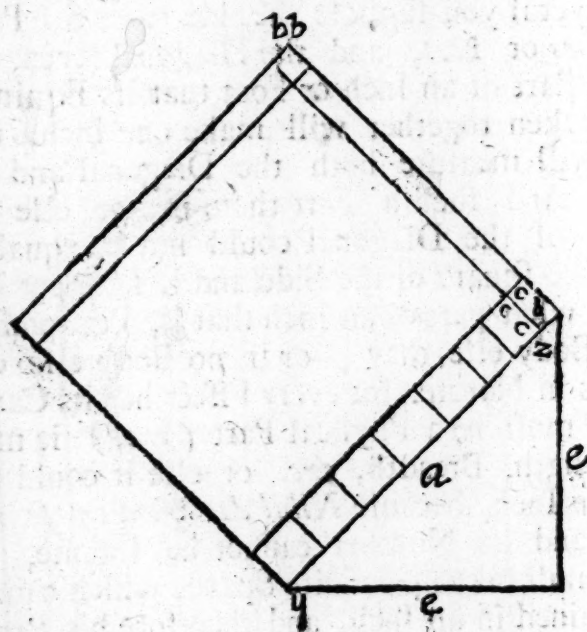
But tho' such Arguments that are deduced from an *Infinite Division*, or a *Mathematical Point* be *Sophisms*; yet I do not deny, but the Supposition of a *Mathematical Point*, or of an *Infinite Division*, as 'tis used in Demonstration, or the Measuring of Quantity, may be very useful, if not necessary: But as Infinite is here used, 'tis, very

very strange to me, to find either Mr. Norris or Mr. Malebranch, arguing from it as an Actual Thing, and from thence deducing, or proving the Extent of the Capacity of the Soul or Mind, or the Reason it consults. For by this, if the Reason or that Power which God has given us, to Observe, Compare and Infer, be Ours, (according to him) 'tis Infinite; if it be not Ours, we have none, and therefore are not answerable for any unreasonable Action: which are Consequences, I think, too great for so weak a Foundation.

Nor am I yet convinc'd, that those Lines generally esteem'd Incommensurable, are really such:

For the $7+7$, in the Instance above, is but 49, which is equal to twice $5+5$ or 50, as the Square of the Diagonal is to the Square of the Side; yet if you suppose the Side to be five Parts, as Inches or Feet, and the Diagonal seven, and such a Part of an Inch or Foot, that its Equimultiples taken together will make one Inch, that Part will measure both the Diagonal and the Side: And such a Part there is, or else the Square of the Diagonal could not be equal to twice the square of the Side, and if I cannot Nominate what part of an Inch that is, 'tis possible some Body else may; or if no Body else can, yet it is in Nature, for every Effect has its Cause. And it must be a Physical Part (*i. e.*) it must have Length, Breadth, &c. or else it could not make an Inch, because *Nihil dat quod in se non habet*, and its Number cannot be Infinite, for then it must take up Infinite Space, which cannot be contained in an Inch, and therefore his Proposition, that a Continuum does not consist of Finite Points is False, and consequently a Point or Part will Measure both the Diameter and Side of a Square.

To find out what part this may be, let e be the Side of a Square = 5 Inches, let $yz = a$, be = 7 Inches; and the difference betwixt a and the Diagonal be b ; then $a + b =$ Diagonal of ee , then $aa = 49$ Inches, and $2ab + bb =$ or $cc =$ one Inch, which being added to 49 is equal to 50 or to twice 25, as the Square of the Diagonal, is to the Square of the Side: Then bc , or $\frac{2ab}{14} + \frac{bb}{14} = \frac{cc}{14}$ then $\frac{bc}{14} + \frac{b}{14} = \frac{cc}{196} = xx$, than $b + \frac{b}{196} = x$; here the 196 Part of b Measures b , and bb , and bc , and x , and xx , and $\frac{cc}{14}$, and cc ; and cc , Measures aa , and ee , which



are all the Parts of the Side, and of the Diagonal of ee , (and of the Squares themselves, and therefore

therefore the Side of a Square and its Diameter are *Commensurable*: Since 'tis possible to find out a Quantity that will Measure both, and leave nothing, which was to be proved.

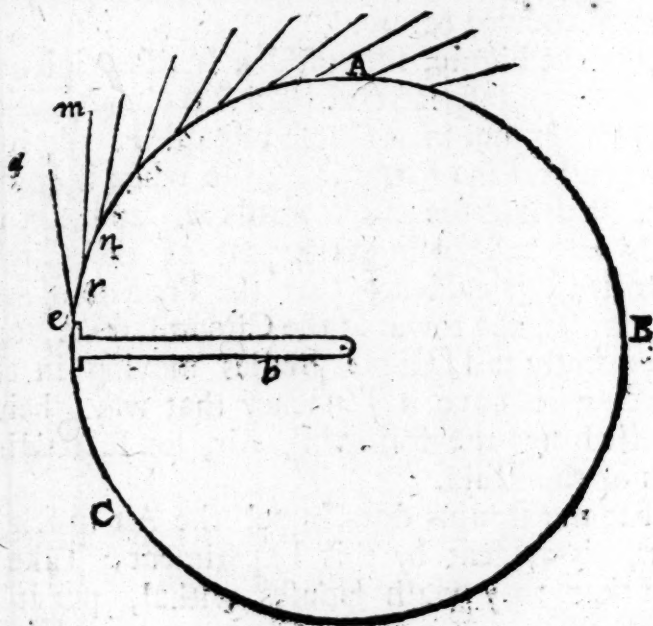
But 'tis time to return from so long and so great a Digression, which I hope the Reader will pardon; since if these are Errors, they are Errors attended with such Consequence, that I think they ought to be detected so soon as they are seen.

Bodies are said to be *Centrifuge*, when the Medium in which they are, being put into a Violent Rotatory Motion, drives them from the Centre towards the Circumference: Which does not happen, because there is any Tendency in themselves, (as the Word imports) from the Centre, but because the Pressure of the Air on that side is lessened, or taken off by the stroke of the Radius, which being lessened on that part, the Expansion or Resistance of the Air on the opposite part, will drive them in that Line, where the Pressure of the Air is taken off, as has been shewed before.

As in the Figure, suppose *b*, a Radius violently moved about describe the Circle *ABC*, and striking the Air at *e*, not in a Circle towards *r*, but into that Right Line towards *d*; so when it comes to *r*, it drives the Air towards *m*, and not towards *n*, and so in every part of the Circle. By which 'tis evident, that the Pressure of the Air, is lessened towards the Circumference, and consequently all Grave Bodies moving in the Fluid, will have a Tendency that way, being Impelled by the following Air, or succeeding parts of the Fluid.

That the Radius does Impel the Air in Right Lines, is evident by this Experiment: Take a Mop that they wash Houses withal, put it in
Water

Water, and when 'tis full wet, take it out, and whirl it about then briskly in your Hands, and you will see the Water not turn in a Circle round about the Mop, but fly off in Right Lines every way from the end of the Threads, like *d, m, &c.* in the Figure: which comes to pass for the very same reason, that an Arrow flies in a Right Line from a Bow, or a Bullet from a Gun, which has bin showed above. For when the Impulse exceeds the Gravity of the Body, the Gravity of the Body is taken off, and the Body leaves the Centre, and tends that way where the Air impels it, and it finds less resistance, as the *Mercury* in the Cistern, is impelled into the Tube of the *Barometer*; and for this Cause 'tis, that a Cup of Water, &c. set in a Wheel, which being turned briskly about, the Water will no more fall out, when the bottom of the Cup is upwards in the Zenith, of the Wheel, than when 'tis downwards in the



Nadir,

Nadir, because then the Impulse is upon the Surface of the Water pressing it to the bottom, which then bears strongly upon the Wheel.

For the same reason 'tis that a Ship Sails, before the Wind, for as the Wind by driving the Air to any Point, lessens its Spring, betwixt that Point, and that side of the Sails of the Ship that is next to it, so its Spring is proportionably encreased upon the other side of the Sails, which adding Weight there alters the Equilibrium, and presses the Ship forwards towards the Point.

This Pressure, if the Spring of the Air were totally taken off, would be equal to the Weight of so much *Mercury*, as would cover the Sails 30 Inches deep, or so much Water as would cover them 35 Feet deep : which would undoubtedly sink the Ship down right. But that I conceive it never is, but only lessened, and therefore the Celerity of the Ships Sailing, is in Proportion to the weakened Spring of the Air before it, or the Pressure behind it, which is Equivalent ; so that if we had but a way to Measure the Weight of the Wind, or Air upon the Sails, it would be easie to know how far a Ship would run, with any Wind in such a Time.

Which I conceive may be done, by having a small Sail, as suppose of a Yard or two Yards Square, placed in a convenient part of the Ship, whose bottom should be fixt with Cords, to such Instrument as Butchers have to Weigh their Meat, made in the Form of a Syringe, with a Spring within it, to which the *Embolus* is fixt, which *Embolus*, has a Ring at the Top, by which they hold it, and hang the Meat upon a Hook fixt to the Box, in which the *Embolus* and Spring lie : When the Meat is upon the Hook, its Weight over Powers the Strength of the Spring, and
causes

caufes the *Embolus* to draw, which by Marks upon its Side fhews the Weight of the Meat. In like manner, if the bottom of the little Sail, were fixt to the Ring of fuch Instrument, and it by its Hook to its Maft, &c. the Wind Preffing upon the Sail, would caufe its *Embolus* to draw, and fhew what Weight of Wind preft upon the Sail. This being known, Obfervation would quickly fhew at what Rate, a Ship having fuch Sails, and Drawing fo much Water, would run with fuch a Wind ; and this Instrument being constantly obferved, would constantly fhew the Alteration of the Preffure of the Wind upon the Sail, and confequently the Ship's way. Which being know, the *Longitude* would be likewise known, for then you have two Sides to find out the third.

How far this may be Ufeful, I cannot tell, but baring Currents if duly obferved, it feems to me, as if it would fhew the Rate of the Ship's way, in all Alterations of the Wind, tho' but for a *Minute* or *Second*.

C H A P. XXXIII.

3dly. **T**HE Doctrine of *Hydraulics* depends upon this, that the Preffure of the Atmosphere, is equal to a Pillar of Water 35 or 36 Feet high, as has bin fhewed already, and has bin demonftrated by the Honourable *Robert Boyle* paft all exception. And therefore I fhall only endeavour here from it, to deduce the Caufe of
Springs,

Springs, not only in Plains all over the Earth, but on the Tops and Sides of most Hills.

For supposing (as has bin before shewed) that as the Terrene and Ponderous Parts of the *Chaos*, subsided to the Centre, so they forced the Watry Particles to the Circumference, which as they fell into each other, would Unite and form Channels in their passage to themselves, especially near the Surface of the Earth, to all parts of which they equally tended; and consequently to that part where the Sea settled; which therefore must have communication with them, except their Mouths may seem to be stoped by the Rolling of Sand, in the time of Tide, over them; but this may be presumed to be only the Shores, the Main Sea being too deep to be thus agitated; but if it were, Sand is a substance that is so far from stoping their Mouths, so as to hinder the passage of Water out of the Seas into them, that 'twill imbibe Water (even where 'tis not forced) to that Degree, as to make it Ascend must above its wonted Level,

Now supposing the Sea thus to have communication with those Water Channels, that at the first Settlement of Things opened their Mouths into it, it by its Weight will Press the Water contained in them, back again into those other Channels, that they have Communication with, near the Surface of the Earth, where Channels are so numerously inserted and interwoven like a Net, that it cannot be supposed that one should run far, without interfering or falling into another, (by way of *Anastimosis*) there scarce being a Yard of Ground free from them, as is manifest by our Wells and Pumps: it being a very hard matter to sink a Well in any place 40

or 50 Feet deep, without meeting with some of them.

And if so, the Sea having Communication with some of them, must with all, (the the Waters may be of very different Tasts, by being impregnated with Mineral Particles in one Place, and having them precipitated in others,) and therefore the Sea thus Communicating with the Springs, will be sufficient to supply all of them with Water, that are not above the Globular Level. There being many Hills that seem high by reason of the flat or low Ground about them, whose highest Springs may be supplied from hence. But because the Pressure of the Atmosphere is equal to the Weight of 36 Feet of Water, the Sea will supply any place with Water, not above 36 Feet above the Globular Level, to which the Sea Water being loaded with Salt, and by that means having its Weight encreased, may make a considerable advance.

And after that if there are any Springs above this, probably they are supplied by Rain, Snow and Vapours, but chiefly by Snow, which by reason of the Height of those Hills, is less exposed to the Reflexion of the Sun's Beams, and more to the Frigorific Particles of the Middle Region, and therefore is less apt to Melt.

2dly, The Dryness of the Soil, it being exposed to no Moisture but just what falls upon it, facilitates its lying there to the hottest Months, at which time it being Melted by the then greater Force of the Sun, may cause those Springs to continue all the year round.

I am sensible that 'tis the Judgment of very Learned Men, that Rain, Snow, and Vapours, are not only sufficient to supply these ; but all other Rivers, Springs, and Fountains, and Mr. *Halley* and others, have demonstrated that there is more than enough to do this, Evaporated every Day by the Heat of the Sun from the Seas, but they do not account for what falls into it again in Rain.

For *First*, As the Sea is abundantly bigger than the Earth, as appears by our Maps, so abundantly more Rain, purely upon the account of its bigness, falls into it again ; and if it be Objected, that as 'tis bigger to receive Rain, so 'tis bigger to supply Vapours ; I answer, that great part of it lies so far distant from the Equator, especially in its turn, as the Sun approaches the *Tropics*, that very few Vapours can be there raised. *2dly*, The Coldness of the Air is there such, that probably may Condense the Vapours as fast as they are raised between the *Tropics* ; which work will be much farthered, because the Sea consists of like Particles with these Vapours, that are from thence raised ; which will therefore more easily Unite again, by reason of the Congruity of Particles : Which is the reason that we so often see *Frogs*, more especially upon Rivers, and Lakes, Sea, and Sea-Coasts.

3dly. A great part of the Vapours raised at Sea, and dispersed to the Land, turn back again at Night to Sea, by reason of the greater Condensation there ; (as has bin shewed before, upon Captain *Langford's* Observation of the reverse of the Wind every Night from the High Lands,) so that little in respect of the Whole is Condensed at Land, and what falls there, will be Imbibed by the Roots of Vegetables, which according to the account that we have already given, from Dr. *Woodwards* Experiments, require at least 50 times as much as their encrease, to support their *Vegetation*. And if we compute how much of what we Eat and Drink passeth by Urine, Stool, Spitting, Breathing, Perspiration, &c. we may have reason to think, there is as great a disproportion betwixt the Vehicle, and what is assimilated to the Bodies of Animals, as in Vegetables ; and if we suppose 50 times as much spent this way, as the encrease and repair of all Animals, Vegetables, and Minerals, which after various Circulations thro' their Pores, is perhaps most of it wasted again to the Seas before 'tis Condensed, especially in the Hotter Months ; the Remainder will be so far from being capable of supplying the Rivers, Springs, and Fountains, that 'tis probable that they must help to support these, or Argumentation and Nutrition would cease.

But 'tis objected, that if Springs, &c. were supplied by the Sea, that they would either be Salt, or if the Salt were Precip-

precipitated their passages would be Stopped by it : To which I answer, 'tis possible Salt may be Precipitated by the Sound in the bottom of the Sea ; which seems to be confirmed, by what Mr. Boyle relates of the Divers, that under the Torrid Zone, have brought several Lumps of Salt from the bottom of the Sea ; and he says farther, that the like Lumps of Salt have bin discovered in the bottom of the Sea near the Mouth of *Gibraltar*. This may again be washed off by a violent Agitation of the Sea, especially near the Shores, where the Sand is carried backward or forwards by every Tide : Which may again wash away the Salts, and thereby hinder it from Obstructing the Passage of Water into the Earth.

Or 2dly, The Salt Water may run in large Channels into the Earth, and be Precipitated where it meets with proper Soil for that purpose, in Saline Rocks (as in *Cheshire*) and Mineral Beds ; and when it has so done, the Water may form it self new passages to all parts of the Earth ; even as when a Vein or Artery is tyed up, the Blood finds new Passages to Circulate in ; and this I am more apt to believe, First, Because there are Briny Springs, such as in all our *Wiches*, which probably have their rise from those Rocks, which Rocks must be repaired from the Sea, or in time they would be wasted, and the Salt in those Springs lessened, contrary to Observation. 2dly, Because there are scarce any Springs but what are more or less Impregnated with Saline Particles. And 3dly, Because this seems absolutely necessary to Vegetation ; for if the Earth had not a fresh supply of Saline Particles from hence, its Surface would grow Barren, if its Saline Particles were perpetually washed away without any reparation, which can be supplied no other probable way.

I shall next consider the Power or Operations of these Active Particles upon the Humane Body, or the Body of an Animal ; First, As they Rarefie or Condense the Blood, and its Juices. Secondly, As they Relax or Intend its Fibres. Thirdly, As they Press upon its Surface. But first I must proceed to the Six Days Work, and consider the Body of the Animal it self ; and this I shall defer to another Paper.

